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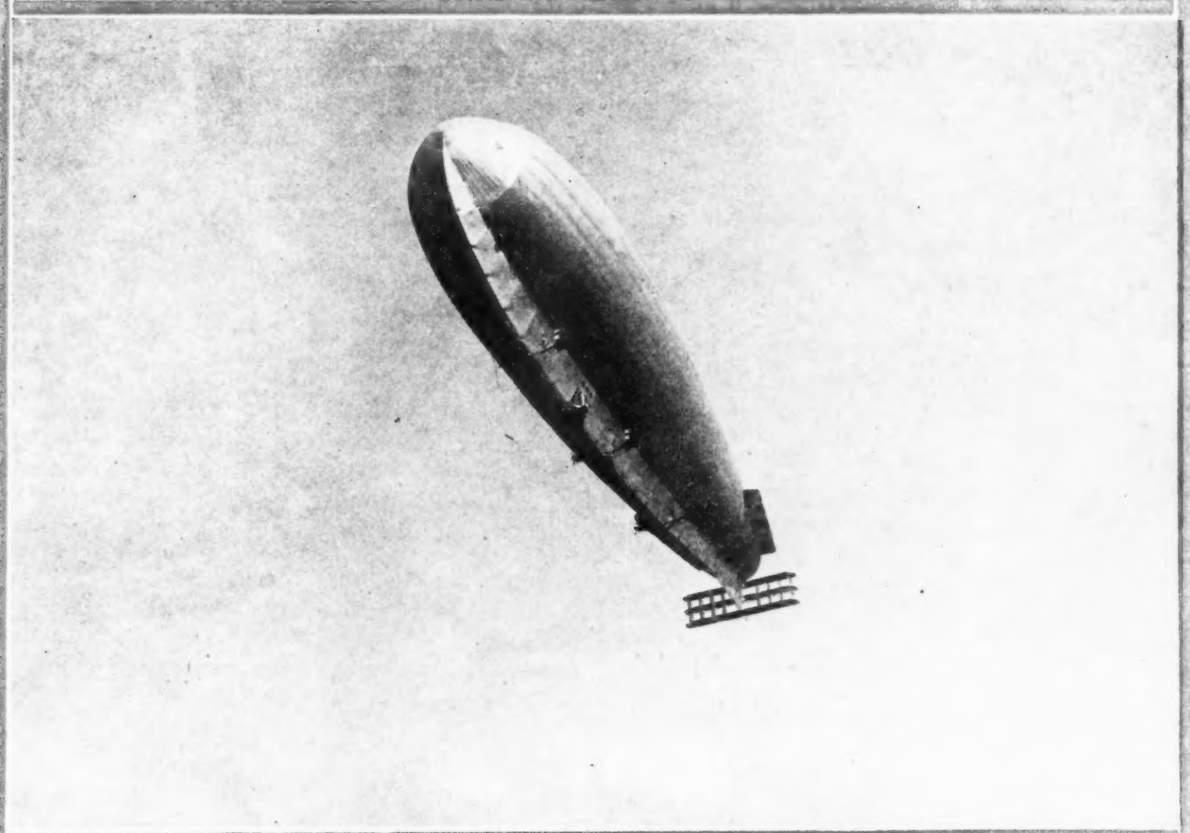

The Italian 37-Ton Airship Roma in Full Flight During Her Trials

VOLUME VIII
Number 9

SPECIAL FEATURES

NEW GLENN L. MARTIN TORPEDO PLANE
BAKELITE MICARTA PROPELLERS
THE ITALIAN SEMIRIGID AIRSHIP ROMA
THE LOUGHEAD SPORT BIPLANE

Three Dollars a Year

PUBLISHED SEMI-MONTHLY
BY
THE GARDNER, MOFFAT CO., INC.
HIGHLAND, N. Y.
HARTFORD BUILDING, UNION SQUARE
22 EAST SEVENTEENTH STREET, NEW YORK

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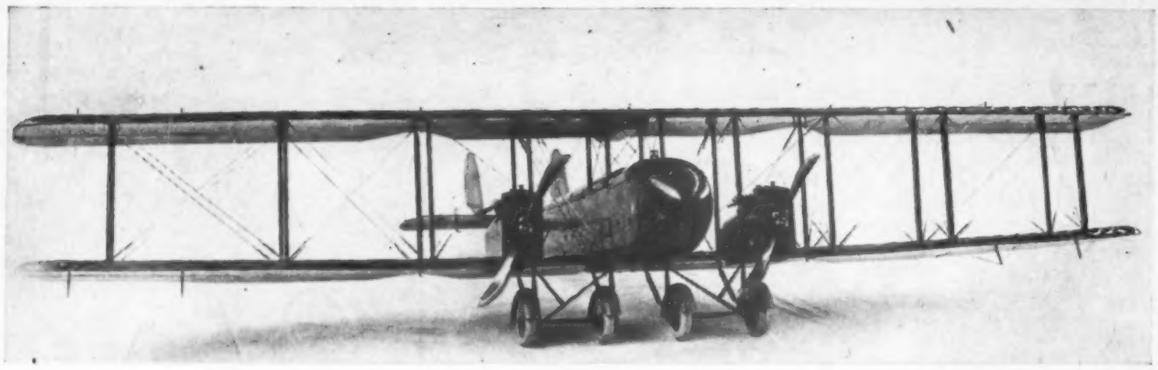

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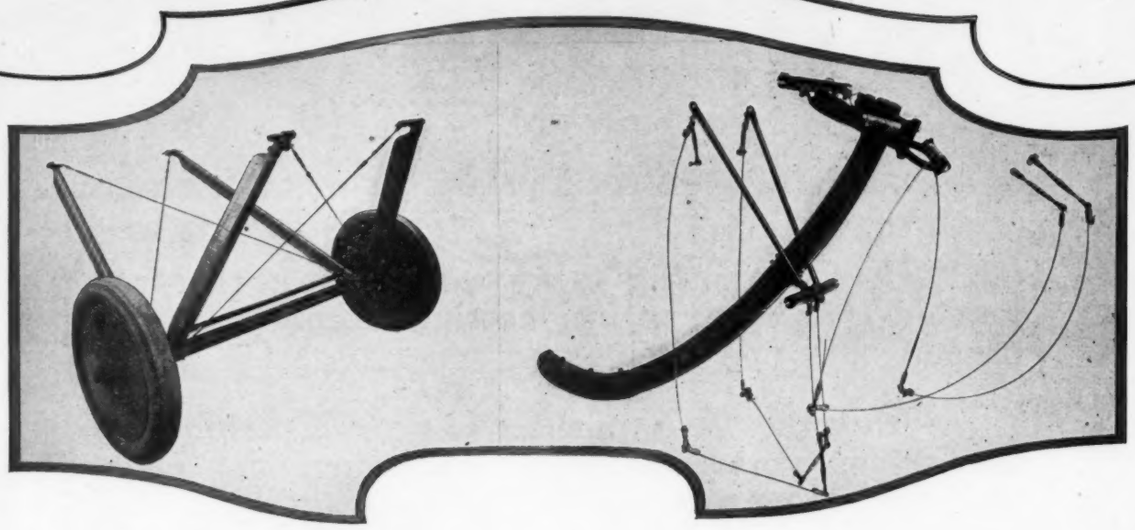

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1-Loening Monoplane U.S.Army

FOR BOTH ARMY and NAVY

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Hartzell Walnut Propeller Company October 25, 1919
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In reply to your letter of the 21st instant we take pleasure in enclosing photographs of three Loening Monoplanes -- two land and one water machine.

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All of the above machines were equipped with Hartzell Liberty Propellers. We take this occasion to advise you that the performance of these propellers has been most satisfactory.

Yours very truly,
Loening Aeronautical Engineering Corporation
A.L. Loening
Vice President and Treasurer

AFL/W
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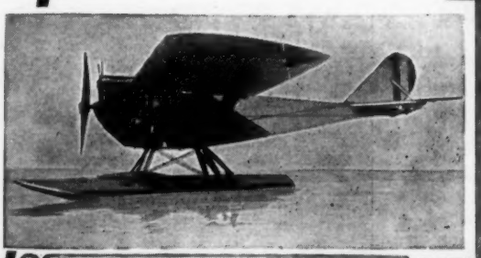

3-Loening Seaplane

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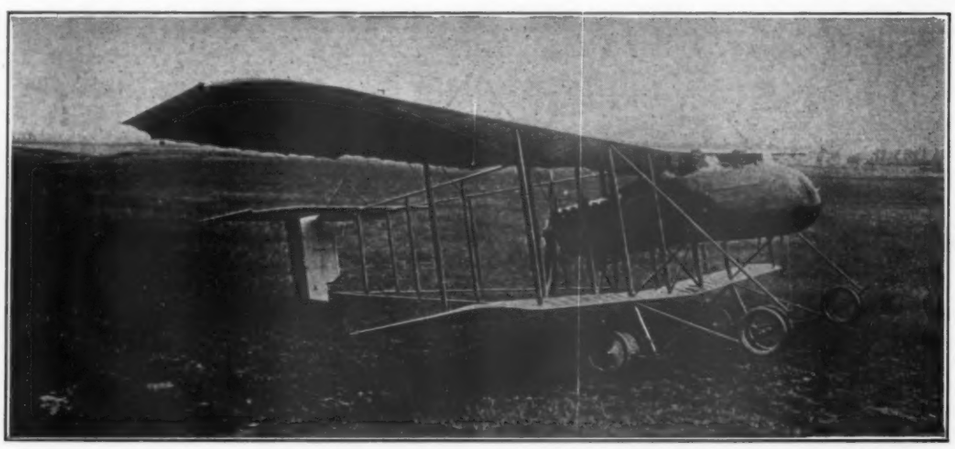

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JUNE 1, 1920 VOL. VIII. NO. 9

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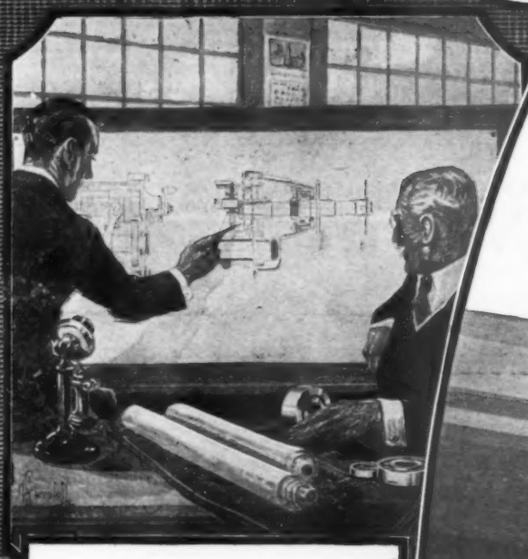

THE importance of the correct choice of bearings is all out of proportion to the cost or size of that bearing.

A bearing failure may be very far-reaching in its effect. The gears that it locates and supports may be ruined, if life *itself* is not endangered.

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AVIATION AND AERONAUTICAL ENGINEERING

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Vol. VIII June 1, 1920 No. 9

THE rules and regulations for the airplane and seaplane competition the British Air Ministry will hold in the coming summer have just appeared. Certain technical requirements are of interest.

In the prescribed number of instruments, it is particularly interesting to see that the turn indicator is included. This instrument has evidently passed into general use.

One paragraph reads, "No landing apparatus may be used which, in the opinion of the judges' committee, would be liable to cause undue damage to an aerodrome." A claw, attached to the machine, as used on certain German machines, will not be allowed, but the ordinary knife type on a tail skid will be allowed. There is a tendency amongst American designers to design tail skids approaching claw form, and the Air Ministry advisedly attempts to check this tendency.

For twin engine machines, the rules call for a get-away with half load, with one engine completely shut off. The British are lenient in calling for half a load. Requirements in this country for twin engine machines have been for a get-away with full load.

Another requirement calls for flying at cruising speed for 5 minutes, without the use of any controls or stabilizing devices. The committee getting up these rules would certainly not include such a requirement unless they knew that stability of this character is quite possible of achievement. It may be safely said that this is a requirement which should be imposed on all commercial machines.

Machines are expected to stand unattended in a wind of not less than 10 m.p.h. It is not at first evident that anything can be provided for in the design of a machine to meet this requirement. Perhaps it would help if the body were very low, and the wing skids of generous proportions.

Carefully graded marks are allowed for various features, such as speed, landing, get-off, airplanes in flight, economy, and general features have been developed.

The rules on the whole are satisfactory, and a competition of this character is far more satisfactory from a design point of view than any speed test or even a cross country test.

The Italian Airship Roma

The new Italian airship Roma, a description of which apears with various illustrations in the present issue, should elicit more than passing interest on several counts.

The fact that the Roma is by far the largest semirigid ever constructed—its size being about twice that of its largest forerunner—would alone be worth mention. It was hitherto assumed that the largest "sensible" semirigid was in the neighborhood of half a million cubic feet capacity which was due mainly to the belief that beyond that size the ratio of disposable lift to gross lift would become too unfavorable for practical purposes. The Roma upsets this assumption by having an efficiency ratio of over 51 per cent. This is a whole lot better than that of the British R.34, for which ship the efficiency ratio is only about 45 per cent, although its size is some 40 per cent larger than that of the Italian semirigid. It may be argued that the R.34 is not by any means the last word in rigid construction, for the German Bodensee, only one third the size of the former, has none the less an efficiency ratio of 45 per cent.

This argument is however rather misleading, for it should be noted that the Roma is by far the most heavily engined airship in existence, its horsepower aggregating 2,400, which was that of the Zeppelin L-70, a ship twice the size of the Italian vessel. That with such a powerful propelling apparatus the designed speed is to reach 80 m.p.h. is not to be wondered at, but the perfect streamline of the hull should be a great contributor to this performance. And here it may be remarked that the fineness ratio of the hull of the Roma is 5 to 1, that is, much smaller than that of the best airship streamlines in use. For the Bodensee, which is "fatter" than any previous rigid, the fineness ratio is 6.8. Italian airship constructors have always maintained that all contemporary airships but their own had too large a fineness ratio and attributed the high speed/horsepower ratio of their vessels to this very reason. It will be interesting to watch whether the trials of the Roma will again confirm their previsions.

Another interesting feature of the Roma is the use of the so-called Verduzio ridge, that is, a longitudinal lobe on top of the envelope formed by rigging guys in the manner of the Astra-Torres, from which suspension cables run to the keel girded. As the latter is of the well known articulated type, the Roma may be regarded as a compromise between the prewar Military type of Italy and the experimental Verduzio, and probably embodying the best features of both.

In view of the many novel features above enumerated the trials of the Roma will be watched with keen interest by all concerned with the development of lighter-than-air-craft.

Resistance of Streamline Bodies

Some interesting comparisons are made by a German writer on the resistance of various types of bodies, which emphasize what it is possible to do with stream lining. Thus a plate 37 millimeters square has a resistance equal to that of a stream line body of 12 meters length and 2 meters diameter. It has a resistance equal to 4 uncovered wheels, 55 centimeters by 7.5 centimeters in dimensions, and 8 covered wheels of the same size. Everyone understands the advantages of stream lining, but when the actual comparative figures are set down in this fashion, the results are truly startling.

Heating the Passenger Plane

On an English machine, a small heating radiator has been installed in the passenger cabin. The heat is obtained by utilizing the warm air round an exhaust extension pipe.

The idea is quite simple and is said to be absolutely free from danger of fire. On a cold winter's day, at high speed, absolute comfort is thus secured for the occupants.

Bakelite Micarta Propellers

During the past few years there has been developed for various electrical uses and also for certain parts of automobiles a composition material called "Bakelite" after its inventor, Dr. Backeland. So successful has this material proven that experiments are now being made with airplane propellers built of it. From the results thus far obtained, it is evident that these propellers have several advantages over those constructed of wood.

Bakelite is a harmless and particularly inert composition material derived from the combustion of carbolic acid, cresol, or phenol, and formaldehyde. These when combined in the proper manner form a resin which in its primary state may be either solid or fluid, but in either case is essentially a soft resin easily affected by heat and solvents. If subjected to combined heat and pressure for a sufficiently long time, however, the material is carried over into a hard state not affected by ordinary solvents or temperatures that ordinarily would disintegrate a gum or resin. When in this condition bakelite is but slightly affected by acids or weak alkalies. It will not burn at all readily, but will char and burn slowly at temperatures in the region of 300 to 400 deg. Cent.

Bakelite, when properly formed and hardened under the influence of heat and pressure, is much harder, stronger, and more glass-like than practically any other organic material.

Bakelite Manufacturing Methods

There are two commercial methods of utilizing bakelite. One is to combine it, before heating and forming, with a filler, such as for instance wood flour or a very finely pulverized and prepared wood fibre, and mold the composition to the desired shape in accurately formed steel molds. The other process consists of building up plates or tubes from sheets of material which have been treated with bakelite in the form of a varnish. Automobile ignition distributor heads are good examples of the former method, and ignition wire tubes and similar forms are often made by the later process.

Recently bakelite has been used in combination with strong kraft paper or with cotton, duck, or similar materials in the making of various molded forms. The usual method of manufacture is to run the paper or cloth used as a base over a roller heated to the proper temperature, after coating the base material with a thin coating of bakelite. As this is wound on to the roller it is cemented by the bakelite. Tubes and various hollow sections are made in this way. Irregular hollow shapes are formed by removing the roller or mandrel when the compound is about half set and pressing it to the desired shape when in this condition.

By another method flat sheets of cloth or paper are coated with bakelite and pressed together to form solid blocks of various shapes. The material formed by coating a cloth or paper base with bakelite compound and pressing a number of these prepared sheets into solid blocks is known by the trade name of Micarta. This was developed by the Westinghouse Electric and Manufacturing Co.

Troubles of Wood Propellers

Probably the principal objection to the use of wood for airplane propellers is warping, and the consequent changing of shape, due to unequal absorption of moisture in the different laminations or to inequalities in the rate of drying. It is practically impossible in the commercial manufacture of wood propellers to get all of the laminations of exactly the same moisture content. In addition to the variations in the amount of moisture content, the various laminations are rarely, if ever, of the same density. It follows, therefore, that the rate of moisture absorption of the different laminations will vary considerably with resultant warping and changing of shape of the propeller as a whole. This is particularly true in cold weather on account of the wide differences in temperature and humidity between the cold outdoor air and the air in heated buildings.

Varnish coatings, no matter how carefully applied, do not prevent wood propellers from absorbing or giving up a certain amount of moisture with changes in atmospheric conditions. This has been proven in numerous tests.

Other methods have been tried of protecting the wood from moisture absorption, such as coating the whole propeller with metal-leaf applied over a sizing coat in the same manner that gold-leaf signs are applied to store windows. Electroplating and the application of hard rubber coatings also have been tried, but none of these processes has proven satisfactory. All of these methods add considerable weight to the propeller, and, moreover, are subject to chipping or breaking under comparatively slight abrasion, with the result that moisture gets in at one point and soon disintegrates the whole protective coating.

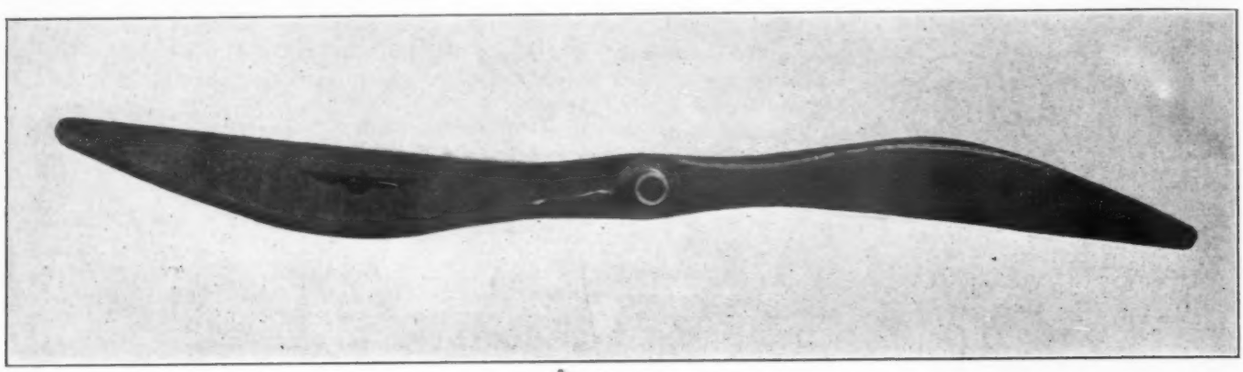


FIG. 1. MICARTA PROPELLER FOR LIBERTY-TWELVE 400-HP. ENGINE. THIS PROPELLER WITHSTOOD OVER 1,300-HP.

Metal Propellers

Various experiments have been conducted, both in the United States and different European countries with metal propellers, but all these tests have proven uniformly unsatisfactory. The most serious fault in a metal propeller is the fatigue of vibration effect frequently spoken of as crystallization. Weight and rigidity are other grave defects. In order to reduce weight, hollow propellers have been tried, but these are impracticable for manufacturing reasons. Attempts also have been made to produce metal propellers of thinner sections than wooden types, but these were not as strong as they should be, and moreover, it was found that reducing the thickness of the section by half resulted in a gain of only about 5 per cent in efficiency.

It is considered possible that metal propellers may prove superior to wood at speeds between 2,000 and 3,000 r.p.m., but it will probably be some considerable time before these speeds are realized in practice, if ever.

Requirements of Satisfactory Propeller Material

A successful propeller material must possess the following characteristics. It must have adequate strength to resist large centrifugal and thrust forces and to withstand sudden

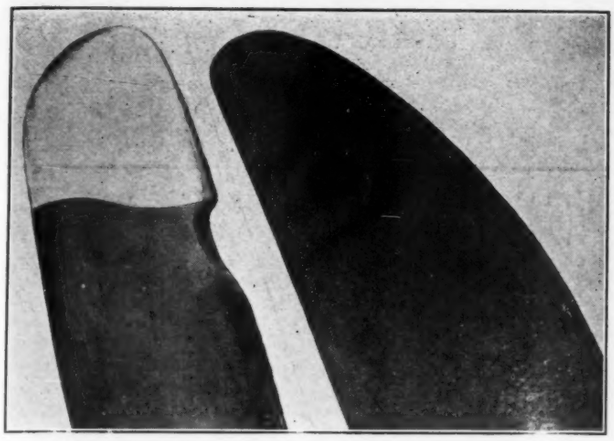


FIG. 2. LEFT—WOODEN PROPELLER, RIGHT—MICARTA PROPELLER AFTER WATER TEST

changes in those forces and in the driving torque without fatigue. The surface must be hard and tough to resist the abrasive action of rain and snow encountered while flying and particles of sand and mud met when taking off or landing. The material must be uniform throughout; otherwise the propeller will have a tendency to flutter or run out of track. Finally the product must have permanence of shape. The blade angles must remain constant and the blades maintain their alignment, to secure a good propeller performance.

Bakelite micarta satisfies more or less completely all of these requirements. The following comparisons may be made between micarta and wooden propellers.

Strength.—Micarta has greater mechanical strength than wood, making possible the use of thinner blade sections with increased efficiency. Its modulus of rupture is from 17,000 to 25,000 lb. as against from 8,000 to 20,000 lb. for wood.

Cracking.—Micarta propellers will not crack or split. The material is suitable for irregular or curved blades and blade forms can be used which would be impossible with wood.

Hard Surface.—Figure 2 illustrates the relative wearing qualities of micarta and wood. Both propellers were run in a water spray at 1800 r.p.m., the wooden one for a few minutes only and the micarta for one-half hour. Practically the only damage done to the micarta propeller was the removal of a little paint from the leading edge, while with the wooden propeller the material was worn away considerably, where unprotected by metal tips.

Permanence of Shape.—Micarta propellers are not affected by atmospheric changes and will hold their shape indefinitely. No special precautions are necessary in handling, storing and shipping.

Uniformity of Material.—One difficulty in the manufacture of wooden propellers is the securing of uniform material. Exacting methods of curing and inspecting the wood are necessary to secure adequate strength and satisfactory flight performance. Micarta propellers are manufactured in such a way that uniform characteristics are assured.

Weight—Micarta propellers have about the same weight as is secured with the use of the better grades of wood. This is possible because of the great strength of the material, which makes possible the use of a smaller hub portion and also a lighter metal bushing. With micarta propellers it is possible to replace the heavy flanges and bolts used with bushings for wooden propellers by four light keys driving direct on the micarta. It is even possible to eliminate the metal bushing entirely if the engine shaft can be modified to permit of the use of more keys.

With micarta propellers it is possible to secure improved flight characteristics by inserting metal straps or wires where additional rigidity is desired. This will be explained more fully later.

One great advantage of micarta over wood is that it does not split and that it is hard enough to stand the abrasion of service without being fitted with metal sheathing. This is of considerable importance in propellers designed for use with high powered engines.

Working Characteristics

In working this material, good results have been obtained with a fine feed and a cutting speed of a little over 100 ft. per min. The cutting tool should have a slight rake. In general micarta material cuts very much like hard wood. In cutting perpendicular to the laminations, as for instance, cutting spur gear teeth, keyways in propeller hubs, etc., it is advisable to back up the material with a hard wood plank to prevent fraying of the fabric where the cutter comes through.

Machining or other working of micarta forms is not always necessary, however, as it is quite possible to form this material to the exact shape desired within quite close limits, provided the molds are properly made for this work and the manufacturing process carefully carried out.

It is possible to mount a micarta propeller directly on the propeller shaft, thus doing away with the metal hub. This not only reduces the weight somewhat, but decreases the number of parts to be made and fitted, which is an obvious advantage in turning out a large number of machines. Perhaps one of the strongest points in favor of micarta as a propeller material is the fact the propellers can be built much more quickly by this method than by making wood propellers in the usual way. Moreover, all of the micarta propellers made from the same mold will be exact duplicates of one another and will be practically finished when they leave the molds, requiring only balancing and slight tuning up before they can be put into service. From a production standpoint, therefore, micarta propellers are much to be preferred to wood propellers made in the usual way, provided that the two types are equal in other respects.

Self-Adjusting Pitch Features

The micarta propeller only needs to be in process one day, but it is, of course, necessary to provide considerable time for building molds before quantity production can be attempted. This is one of the disadvantages of micarta construction, as it is necessary in propeller work to allow from one to two

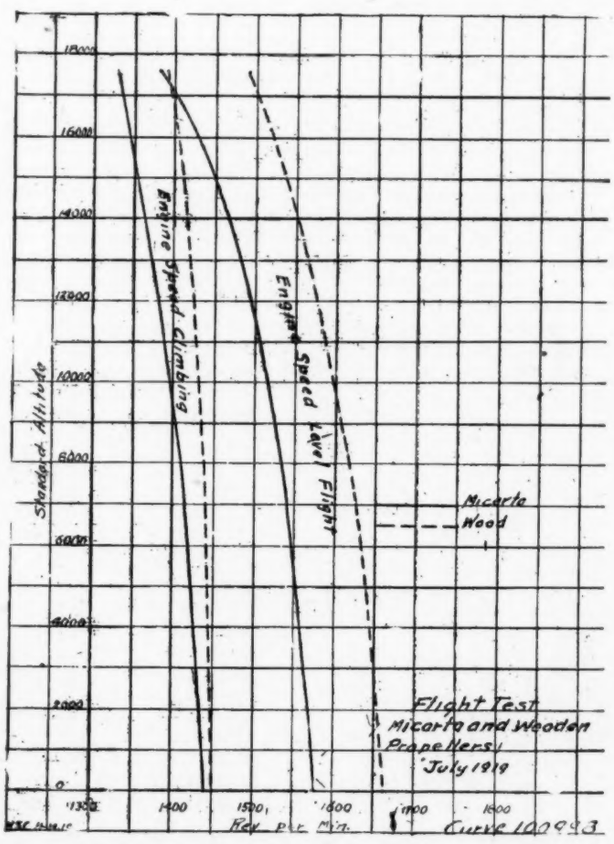


FIG. 3. GRAPH OF FLIGHT TESTS OF WOODEN AND MICARTA PROPELLERS

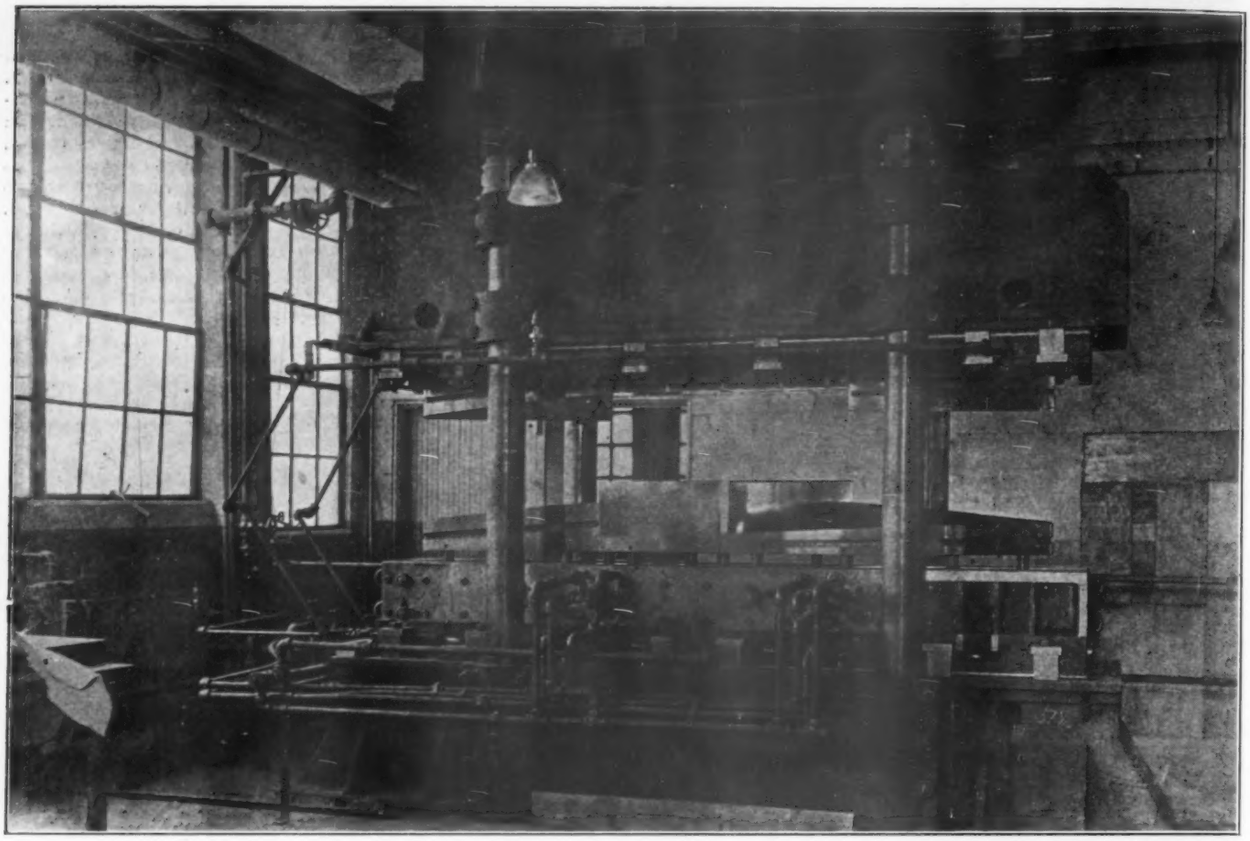


FIG. 4. MOLD FOR LIBERTY MICARTA PROPELLERS. LOWER PRESSING PLATE IN POSITION FOR REMOVING PROPELLER

months for making a set of molds, which means a corresponding delay in case any slight changes in propeller design are found necessary.

By incorporating wire reinforcements in the leading edge of a micarta propeller the virtual center of gravity may be moved forward slightly, which, of course, is not possible with a propeller made of wood or other homogeneous material. By locating the center of gravity slightly nearer the leading edge than the center of pressure, it is possible to provide a self-adjusting pitch feature, due to the elasticity of the micarta construction. The effect of locating the center of gravity forward of the center of pressure is to cause the propeller blade to flatten out slightly under heavy load, and thus decrease the pitch to a certain extent when climbing, while the pitch will automatically increase again under lighter load.

Propeller Hub Keys

It was found in some of the tests that the standard sized propeller shaft key used with wooden propellers and a metal hub, was hardly large enough for use with a micarta propeller. In the latter construction there was a tendency for the keyway to spread slightly and one or two propellers broke loose during tests on this account. On account of this feature, it is necessary to provide a micarta propeller with a somewhat larger key than is used with the wood construction and steel hub. That is the section of the key which fits into the propeller must be larger, but the other half of the key, fitting in the propeller shaft, can be made the same size as for wood propellers and metal hubs. A number of micarta propellers have been made up for test recently. Some of these were made with paper base, and others with duck base, the latter proving much more satisfactory in tests. One or two samples have also been made with piano wire molded into the leading edge which seems to increase the strength materially in some directions.

Bakelite is molded to an exact angle in a special mold. These same molds could, of course, be used for the making of large numbers of propellers of the one design.

The most satisfactory method of making micarta propellers has been found to be to press together tightly five or six sheets of cloth or paper impregnated with bakelite, forming a board. The boards thus formed are then sawed out in the shape of propeller laminations in exactly the same way that the laminations of wood propellers are cut out. About 175 such laminations are used in the manufacture of a propeller 4 in. deep at the hub.

These laminations are laid in the mold and the plunger of the mold is inserted and brought down to press the material into the final shape of the propeller. For this work a large press with a capacity of about 1000 tons is required. While the material is in the press, it is heated by means of steam coils to a temperature of about 350 deg. Fahr. and the combination of pressure and heat first cements and then congeals the bakelized material into a solid mass. This process requires from 3 to 4 hr.

Accurate Molds Required

It should be mentioned that the forms or molds are machined very accurately so that the plunger just fits into the main body of the mold and when the plunger goes down to the bottom of its stroke, the hole in the mold is of the exact shape and size of the finished propeller. A propeller made in this manner will have a smooth, highly polished surface, depending, of couse, on the finish of the interior of the mold. After removal from the mold, the propeller must be bored true and key-slotted at the hub hole and balanced, and is then ready for installation on the plane. Micarta propellers are balanced in practically the same way as wooden propellers. In inserting balancing plugs however, it is important that they be located properly as there are one or two locations which would weaken the hub of the propeller considerably and might cause failure.

Five micarta propellers designed for the Curtiss OX-5 were tested by the Air Service to destruction by running for 10 hr. at 1800 r.p.m. and then increasing the speed until failure resulted. All of these propellers broke at a point about

32 in. from the axis, which checks closely with the computed stress. In addition to these five propellers, another made of paper micarta was tested to destruction. This propeller failed at the hub at a speed of 2200 r.p.m. and owing to this failure it was decided to make no further tests with paper micarta, but to concentrate on the duck construction. Another propeller was made with reinforcing wires in the leading edges. This propeller was keyed direct to the shaft without a metal hub and was run 10 hr. at 1800 r.p.m. and then speeded up to 2350 r.p.m. without showing any signs of failure. This propeller was designed for 90 hp., but at the maximum speed absorbed slightly over 800 hp. without showing any defect.

Comparative Weights

The weight of this last-mentioned propeller is about 39 lb. as compared to 29 lb. for the Curtiss mahogany propeller and hub of corresponding design, and 35 lb. for the Paragon oak propeller and hub. The weight of the micarta propeller can no doubt be reduced by further experiment, but this has not been considered necessary so far.

Additional Tests

In addition to the above tests, a number of others were run by the Air Service at a later date with the following results:

Hub test to determine roughly the strength of the hub. Eight 1 in. holes were bored on a 2¼ in. radius around the tapered hole for the engine shaft. Two of these holes were spaced 22.5 deg. on either side of the transverse axis of the hub and the eight holes were 45 deg. apart. This propeller was run at speeds increasing in steps of 200 r.p.m. until it broke through the hub at 2200 r.p.m. Failure occurred through two of the 1 inch holes and the hole for the engine shaft. This propeller as run in the test weighed 40.5 lb. No angles were measured in this test.

Machine gun fire test. This test was run primarily to determine the effect of machine gun fire on the strength of the propeller. Regulation 30 cal. ammunition was used. Sixteen shots were fired in a radial line through one blade.

The test showed that the thirty-three bullets fired through the propeller blades decreased its maximum speed only in the ratio 20 to 22. The pitch change as figured from deflection readings was practically the same as for the uninjured propellers. The horsepower absorbed as different speeds was the same as before the shots were fired through the blades. No angles were measured on this propeller.

Sand and water test. One propeller was tested by running 3.3 min. in a water spray and at the end of that time showed no appreciable wear or other bad effects. After the completion of the water test the same propeller was run at 1600 r.p.m. in a sand blast. Two runs were made, one of 1 min., the other of 53 sec. The sand blast was shot upward from below to parallel conditions encountered in actual service when starting an airplane. After these runs the propeller had a sanded appearance but the wear was not noticeable.

Test for distortion. A micarta duck propeller was made with twisted laminations and reinforced with steel piano wire along the leading edge. It was run for 10 hr. at 1800 r.p.m. and at the end of that time showed very little wear. The blade angles of this propeller were measured at various stations both before and after the test.

Seven test propellers were made up and sent to an Air Service flying school. One of these was run for 50 hr. on a test block without showing any deterioration and the other six were tested in actual flights. The worst trouble encountered with these propellers was the tendency for the key to roll up. These tests showed the necessity of using a larger sized key in micarta propellers than is standard practice with wood propellers and steel hubs.

Two propellers with different keys were tested later at Wilbur Wright Field on the test blocks. Unfortunately, however, one of these propellers broke during the test partly as a result of having been weakened at the hub by improper location of a balancing plug which was in line with the transverse axis of the propeller hub. Examination of the broken hub ends of this propeller showed that the ¼ inch key used had crushed the micarta due to the torque, making a ¼ inch deep slot nearly half way around the taper hole for the engine shaft. This slot together with the hole bored for the balancing plug reduced the area of the working material on one side of the hub to less than half that of the other side.

Micarta Propeller for Liberty Twelve

The experience gained from the JN-4 propeller made possible the evolution of a design for the Liberty engine that possessed adequate strength and good flight characteristics. The equipment for manufacturing this propeller was made so accurately that the first propeller molded was able to withstand what was probably the most severe test ever given a propeller of this size. Extracts from the government report on this test are given.

"This propeller was first run at the plant of the W. E. & M. Co., East Pittsburgh, Pa. on Mar. 15, 1919. A power curve was taken from 1000 r.p.m. up to a speed at which the propeller was absorbing approximately 600 hp. It was then started on a 10-hr. run at that input but was shut down at the end of three hours on account of belt trouble.

"The test was continued at McCook Field, Dayton, Ohio. A power curve was taken from 600 r.p.m. to 1700 r. p.m. in steps approximately 200 r.p.m. each. At 1700 r.p.m. the propeller absorbed approximately 600 hp., and was run at this input for ten hours.

"At the end of the ten hour run at 600 hp. the power curve was continued up to a speed of 2100 r.p.m. At this speed the propeller absorbed a net hp. of 1326. This was as much power as could be put into the propeller with the apparatus available.

"At the conclusion of the power curve up to 2100 r.p.m. the propeller was stopped for inspection.

"It was then started on a 30-hr. run at 1800 r.p.m. at which speed it absorbed approximately 800 hp. The run at this speed was continued until failure occurred."

The main characteristics of this propeller are as follows:

Horse Power	420 (Liberty)
Revolutions per minute	1750
Pitch	6.64 ft.
Diameter	10 ft.
Plane Speed	132 m.p.h.
Weight micarta	67 lb.
Weight with special keyed hub	82 lb.

Correcting the Longitudinal Balance of JN-6H Airplanes

The Engineering Division of the Air Service, McCook Field, recommends as follows for the correction of faulty longitudinal balance in JN-6H airplanes:

Nose heaviness or tail heaviness should never be corrected by the addition of masses, such as boxes of sand or lead weights.

It is recommended that longitudinal balance be corrected by the adjustment of the stabilizing plane within the following limits. This if the lack of balance is so marked that it can not be corrected by such slight change of stagger as can be effected by adjustment of turnbuckles on interplane bracing.

The angle, in the plane of symmetry, between the chord tangent to the bottom surface of the stabilizing plane and the mean chord of the main planes should be not less than 1 deg., nor greater than 4 deg., the stabilizing plane being always at a smaller angle than the main planes. Less than 1 deg. will produce marked statical instability—more than 4 deg. will overload the fuselage and tail structures. It is believed that the best angle for obtaining the proper degree of statical longitudinal stability, provided the center of gravity is at such a location that longitudinal balance is obtained with this angle, is 2.25 deg. Dynamical longitudinal stability is not materially affected by small changes in the setting of the stabilizing plane.

Assuming that, for an aerofoil of the section and aspect ratio of the tail plane on the JN-6H:

$$\frac{dK_y}{d\theta} = .000155$$

(m.p.h., sq. ft. lb.) (θ is angle of attack of the stabilizing plane, in degrees).

The following table may be used in the field for determining proper change in the setting of stabilizing plane:

Difference in setting of stabilizing plane.		Difference in load at middle of stabilizing plane—pounds					
		Gliding			Full power.		
Angle degrees.	Thickness of block at rear spar, inches	60 m.p.h.	80 m.p.h.	110 m.p.h.	60 m.p.h. climb	85 m.p.h,	Mean.
0.5	0.35	8.0	14	26.5	13.0	20	16.3
1.0	0.70	15.5	28	53.0	26.5	40	32.6
1.5	1.04	23.5	42	79.5	39.5	60	48.9
2.0	1.39	31.0	56	106.0	53.0	80	65.2
2.5	1.74	39.0	70	132.5	66.0	100	81.5
3.0	2.08	46.5	84	159.0	79.5	120	97.8

It will be noted that it takes a very small change in the setting of the stabilizing plane to make a big change of balance in full power flight, or at high speed, while a much larger change in setting is necessary to make the corresponding change while gliding at slow speed. The JN-6H, as usually supplied to the fields, is fairly well balanced while climbing under full power—slightly nose heavy at horizontal high speed or on a flat glide, and quite nose heavy on a steep glide. When this condition is indicated, the machine is statically unstable and an increase in longitudinal V will help more than a change of stagger.

For instance, suppose that perfect balance on a nose heavy machine is obtained with various weights for various respective conditions, as follows:

Climbing—balanced without weight.

Flat glide—10 lb. required at tail.

Horizontal flight—25 lb. required on tail.

Glide at 110 m.p.h.—45 lb. required on tail.

Then, if we increase the longitudinal V by putting a block 7-16 inch thick under the rear span, we now have (referring to table) a machine balanced as follows:

Climbing—16 lb. *lift* required on stabilizing plane (tail heavy).

Glide (60 m. p. h.)—Perfect balance.

Horizontal flight—Perfect balance.

Dive (110 m. p. h.)—12.5 lb. on tail (nose heavy).

We have reduced the divergence between the two extreme conditions by $45 - (12.5 + 16) = 16.5$ lb.

A method suggested for correcting longitudinal balance of JN-6H airplanes is as follows:

Suppose the machine is nose heavy: Strap or otherwise attach different weights temporarily to the fuselage at the longitudinal position of the center of the stabilizing plane, and allow good pilots to fly the machine in straight-away flying, changing weights for successive flights, until about the proper weight for longitudinal balance for all-round flying conditions has been obtained.

Example.—Suppose that he finds that the application of 45 lb. at the center of the stabilizing plane brings the machine in perfect balance for mean condition. By reference to the above table, it appears that the rear edge of the stabilizing plane should be raised by about 1.38 deg. or about 0.95 in., assuming that the fixed point is at the two U bolts near the entering edge.

To accomplish this, it will require not only changing the vertical fin and inserting filler blocks at the bolts at the trailing edge, but new wires and changed tube braces will be required where they attach to the front spar of the stabilizing plane (about 13 in. in rear of the entering edge.)

It is not expected that any adjustment of the stabilizing plane will bring the JN-6H into perfect balance under all conditions. In the above table no account has been taken of the relative height of the line of thrust, nor of the relation of slipstream to stabilizing plane. However, if nose heaviness is completely cured under power, it will always be materially reduced for a glide, for the same air speed.

In case the machine is so nose heavy or so tail heavy that longitudinal balance can not be obtained by adjusting the stabilizing plane within the limits indicated herein, it will then be necessary to change the stagger.

For this particular machine a change of stagger of 1 in. on the upper plane, *provided the angle of incidence is not changed*, should correct for about 7 lb. at the center of the stabilizing plane. In other words, a change of stagger of the upper wing of 1 in. is approximately equivalent to a change of the setting of the stabilizing plane of 0.215 deg. or 0.15 in.

—*Air Service Information Circular.*

Book Reviews

AIRPLANE CHARACTERISTICS. By Prof. Frederick Bedell. (D. Van Nostrand Co. 123 pp.)

Written by a physicist and an experienced teacher, this work is an excellent contribution to the elementary study of aeronautics.

Simple as the treatment is, it is correct. The student reading this book will not have to unlearn anything when proceeding to a more advanced study. Perhaps, these remarks do not apply entirely to the stability portions of the book, where the treatment is not quite so rigid.

The glossary of the National Advisory Committee for Aeronautics is reprinted for the benefit of those not familiar with the standard Anglo-American aeronautical terminology. This is an excellent idea and might be generalized by authors of aeronatical textbooks, for it will help towards weeding out many duplicate terms which only serve to confuse the reader.

THE AVIATION POCKET-BOOK, 1919-1920. By R. Borlase Matthews. Seventh Edition, Revised and Enlarged. (Crosby Lockwood & Sons, London)

The author states in this preface that a very considerable portion of the book has been rewritten, its size increased, and, that it has been carefully brought up to date. Nevertheless, Dines' curves for inclined flat plates and Stanton's formula for flat plates are still included. There is, on the other hand, aerodynamical information of the most modern character, and data is given for the latest wing sections. Stability is as sketchily presented as ever. The chapter on structural design now includes special cases of the theorem of three moments, a curve for the strength of tapered struts, and other useful material. The meteorological information is perhaps the best part of the book. There is a good deal of information on electrical clothing, and other electrical instruments. The pages on engine care and maintenance are reliable and clear. A very complete list of engines is given with main characteristics of each. The British A. G. S. Standards are fully covered and would be of use to American designers. A very incomplete bibliography is given. Armament is well treated. The pocket book also gives the main dimensions of typical airplanes and main data on representative airplanes.

While there is considerable improvement over previous editions, the pocketbook is still far from being satisfactory.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. Twelfth Edition. (940 pp., 532 charts and illustrations. A. L. Dyke, St. Louis, Mo.)

This book may justly be termed An Automobile Encyclopedia, as the subject is very fully covered. It is particularly useful from the point of view of repair and adjustment, covering every detail, from the construction and repair of the axle, to the repair of the radiator and top. Every part of the motor and every part of the car is explained in simple language, with very clear diagrammatic sketches. This applies to the engine, transmission and all other parts. Useful hints are given on valve setting, timing, carburetor adjustment, lubrication, etc. Full information is given on ignition systems, and location and correction of ignition troubles. Storage batteries are fully treated and their troubles also discussed. Very careful instructions are given on the operation of the car. Tire repair, building equipment of garage, and adjustment of clutches are very useful chapters.

Any one, mechanically inclined, with this book at hand, can be his own repairer.

INTERNATIONAL DICTIONARY OF AERONAVIGATION. by Ing M. Mele Dander. (171 pp. Ulrico Hoepeli, Milan.)

This is a four language dictionary, Italian, French, English and German. It has a very useful systematic index and the body of the work is divided into suitable parts, such as types of airplanes, atmospheric conditions, flight elements, flight, body, tank, etc., so that the reader is readily able to find precisely what he was looking for. The book seems to be very reliable as regards Italian and French terms, but some of the English words given, such as "helicopter" and "gigantic plane" do not give us complete confidence.

Despite some flaws the book should prove helpful in the reading of foreign aeronautical publications.

New Glenn L. Martin Navy Torpedo Plane

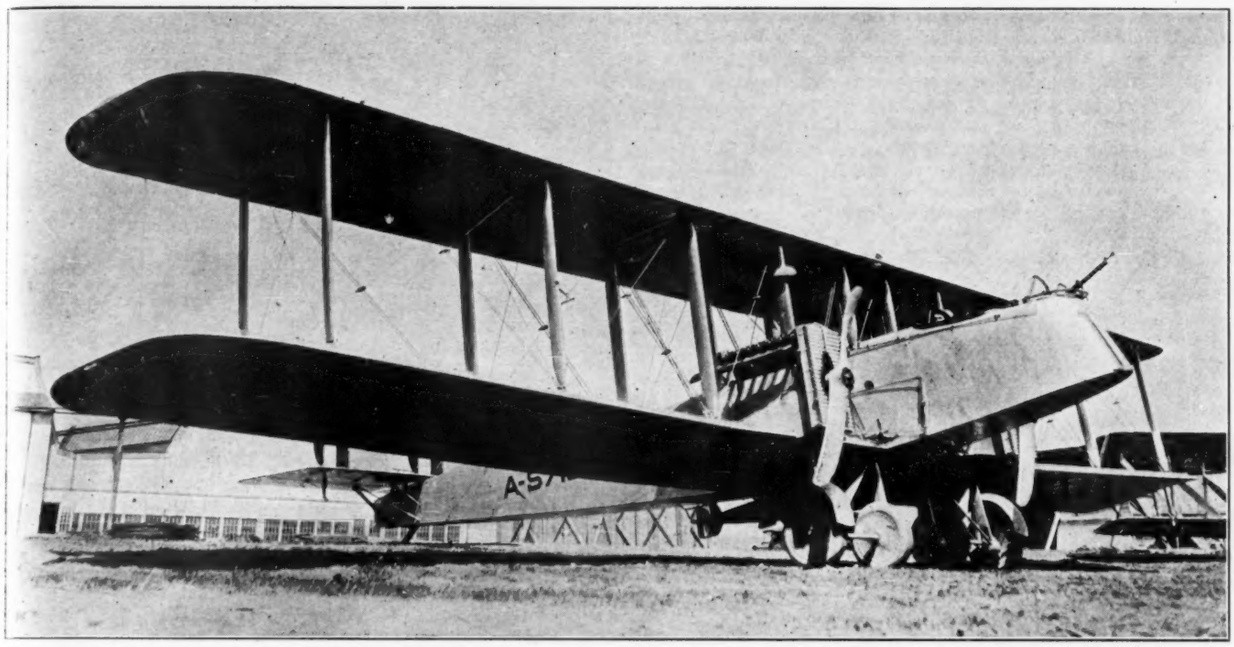


FIG. 1. THREE-QUARTER FRONT VIEW OF THE NEW GLENN L. MARTIN TORPEDO PLANE

The Glenn L. Martin Co. has just completed another new type of torpedo plane of the United States Navy. This plane was given its trial test on May 6, 1920, at McCook Field Dayton, Ohio. Both Army and Navy officials witnessed the trial test and consider the performance of the new torpedo plane an unusual success.

The new Glenn L. Martin Navy Torpedo Plane has a total gross weight of 11,910 lb., which includes a useful load of 4950 lb. In addition to its crew of three men (pilot, navigator, and gunner) this plane carries a 1650 lb.-torpedo, 450 lb. of bombs, two Lewis machine guns, a radio set, a complete equipment of instruments and accessories, and a supply of fuel for four hours operation.

It has a flying speed of 107 m.p.h., and will climb from sea level in ten minutes to an altitude of 5100 ft.

Purpose

The Martin Navy Torpedo plane is the forerunner of a new phase of naval warfare: Its high speed, comparatively small dimensions and unusual maneuverability give it numerous advantages over the present-day torpedo boat destroyer.

This type of airplane is intended for operation either with a fleet or directly from shore stations. Although it is not equipped with floats, it has, in addition to its specially designed landing chassis, emergency flotation bags which are inflated by compressed air. Thus it is adapted for landing either on water or on land.

Operation With Fleet

In operating with a fleet, the plane fully loaded can take off from the deck of a warship or sea sled. Its cruising radius of 480 miles permits of several hundred miles reconnaissance,

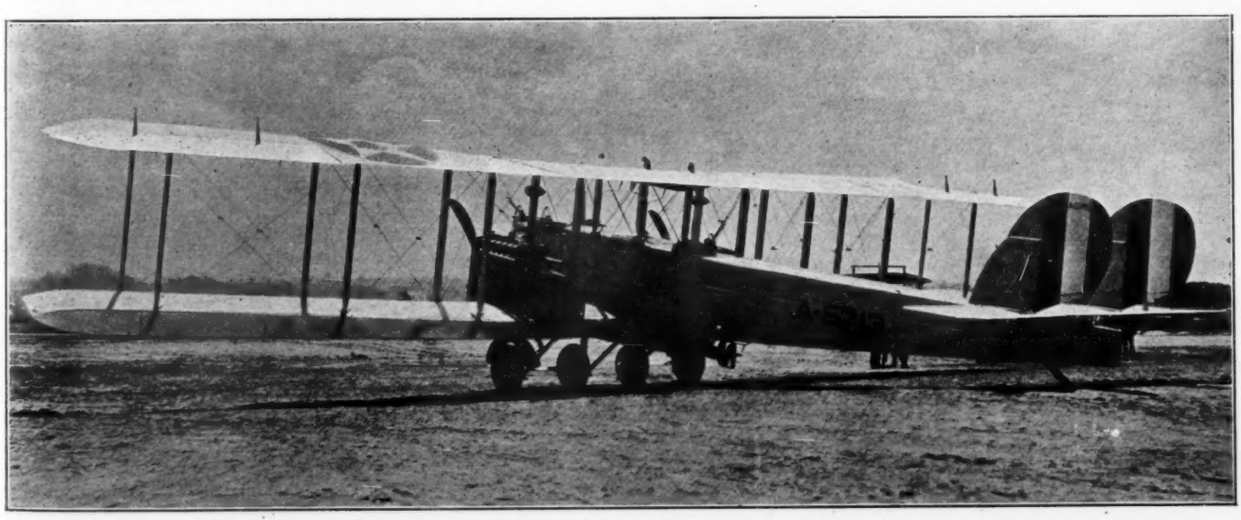


FIG. 2. THREE-QUARTER REAR VIEW OF THE NEW GLENN L. MARTIN TORPEDO PLANE

and by means of its radio equipment accurate communication can be maintained at all times. It can single out the enemy, sweep down and launch its torpedo at close range, thus practically insuring a hit, and then fly back to its mother ship. By means of its flotation bags which are inflated just before landing at sea, it can alight on the lee side of its mother ship and be hoisted on board by means of attachments in the upper wings.

Coast Defense Element

As a coast defense element it can operate from the shore or coast defense station and thus take the place of coast defense guns. The average coast defense gun has a range of about 25 mi., whereas the Martin Navy torpedo plane can fly out to sea a distance of 200 mi., execute its mission and

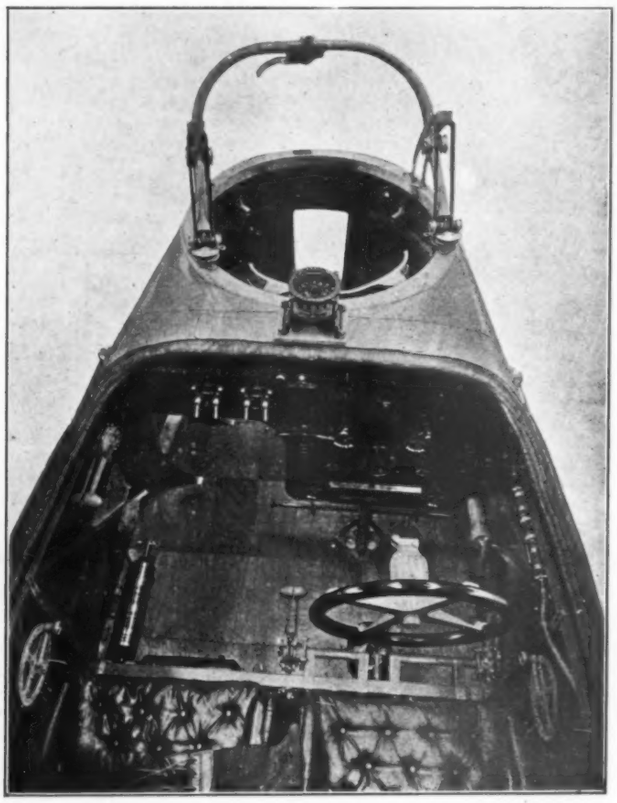


FIG. 3. PILOT COCKPIT AND FORWARD GUN NEST OF THE NEW MARTIN TORPEDO PLANE

at the same time keep the home station in constant communication regarding its operations. Should engagement take place so far out to sea as to make the trip to shore impossible, this plane can land at sea by use of its flotation bags, and signal its home station or any nearby ship as to its location.

Economical Advantage

From an economical consideration twenty Martin Navy torpedo planes can be built for the cost of one torpedo boat destroyer, and can be manned by less than one-third of the men required to operate one torpedo boat destroyer. Therefore the loss of one torpedo plane and its crew of three men is comparatively insignificant in realizing that it is just as capable of sinking a battleship as is a torpedo boat destroyer which costs twenty times more and requires approximately two hundred men to operate.

In comparison with coast defense guns which cost on an average of several hundred thousand dollars apiece and have a range of about only 25 miles, the Martin Navy torpedo plane can cruise out to sea further than any coast defense gun can fire and probably produce more accurate results due to its reduced range of fire.

Design and Construction

The Martin Navy torpedo plane is essentially a land type, twin-motored, tractor biplane. It has several recent developments, such as folding wings, which when folded reduce the

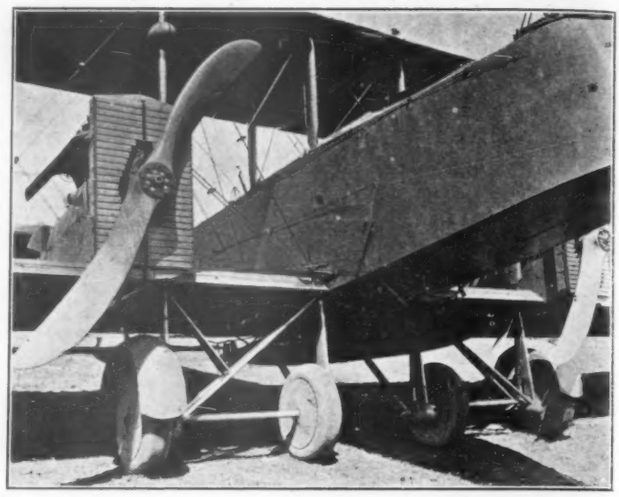


FIG. 4. THE NEW ENGINE MOUNTING AND DIVIDED LANDING GEAR OF THE NEW MARTIN TORPEDO PLANE

over-all width of the plane to 35 ft. 10 in., thus minimizing the space required for housing. Another new feature is found in the landing gear which is divided in the middle so as to permit the torpedo cradle, capable of carrying a 2100-lb. torpedo, to be suspended underneath the fuselage.

The two 12-cyl. Liberty engines are mounted on the lower front wing beams just outside of the first wing strut away from the fuselage. By mounting the motors in this manner the center of gravity is lowered, the flying efficiency is increased, and the motors are made more accessible than they would be if they were suspended from the upper wings or between the struts.

SPECIFICATION

Wing span, over all	71 ft. 5 in.
Span, wings folded	35 ft.10 in.
Length, over all	46 ft. 4 in.
Height, over all	14 ft. 0 in.
Weight, empty	6,533 lb.
Load, useful	4,954 lb.
Weight, gross	11,487 lb.
Crew	4 men
Factor of safety	5 to 7
Maximum	107 m.p.h.
Economical speed (at sea level)	95 m.p.h.
Landing speed	60 m.p.h.
Climbing speed (from sea level)	5100 ft. in 10 min.
Cruising radius	480 m.p.h.
Service ceiling	10000 ft.
Absolute ceiling	12000 ft.

MOTORS

Two 12-cylinder Liberty motors, each 400 h.p., rated at 1700 r.p.m. with self-starters.

ORDNANCE EQUIPMENT

Two mounted Lewis machine guns
Six Lewis gun magazine drums
Thirteen sockets for magazine drums
One 2100-lb. torpedo or the equivalent in torpedo and bombs
Sighting and releasing mechanism

INSTRUMENTS

Tachometers, gasoline gauge, oil pressure gauges, clock, motometers, compass, altimeter, angle of incidence indicator, lateral indicator, dual Liberty switches, air speed indicator, tools.

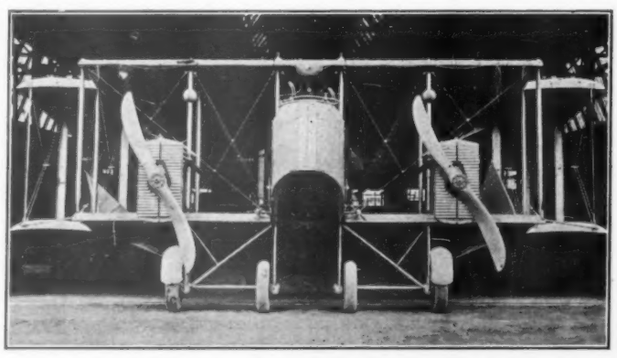


FIG. 5. NEW MARTIN TORPEDO PLANE WITH WINGS FOLDED

Major Schroeder's True Altitude 33,000 Ft.

The Bureau of Standards has just issued an official report on the altitude reached by Maj. R. W. Schroeder on Feb. 27, 1920, at McCook Field, Dayton, Ohio. Major Schroeder used for this flight a Lepere biplane with a Liberty Twelve engine equipped with a supercharger.

It appears from this report that the altitude reached by Major Schroeder, corrected for instrumental errors but uncorrected for air temperature difference, is 38,180 ft., while his "most probable altitude"—as it is officially termed by the Bureau of Standards—which is corrected for air temperature difference is 33,000 ft.

As the altitude of the flight made by Roland Rohlfs on Sept. 18, 1919, with a Curtiss 400 hp. Wasp, was 34,910 ft. (including correction for instrumental errors, but excluding air temperature correction) and 32,450 ft. (including air temperature correction) it follows that Major Schroeder actually climbed higher than Mr. Rohlfs whichever way it is calculated.

The official report of the Bureau of Standards follows:—

Discussion of Data and Instruments

Two Henry J. Green barographs, Identification Nos. 204 and 206, were used. As the clockwork of No. 206 stopped during the flight before the highest point was reached, the pressure curve for this barograph could not be followed throughout, and, owing to the uncertainty as to the highest point indicated on the chart, the result from this instrument was discarded. No. 204 was given flight-history tests on March 24 and 25 in which the flight conditions were closely reproduced. From these results the pressure difference between the ground and the highest point reached was obtained. (Had the average of the results from the two instruments been used, the computed altitude would probably have been increased by about 400 ft.)

The ground pressure existing at the time of the flight as given by the McCook Field mercurial barometer differed so greatly from the result obtained by correcting the pressure given by the Weather Bureau barometer at Dayton for the proper difference in elevation, that the former was discarded as being probably erroneous. This action increases the computed altitude by about 570 ft.

A Boyce motometer was used to measure the temperature of the instruments in the cockpit and a liquid thermometer was used for the free air temperature. These thermometers were not available at the time the flight—history tests were given the barograph. The motometer was later given a flight-history test and an error of + 15°C determined for it at the highest point of the flight. Owing to this error, a correction to the pressure difference as found from the barograph tests was necessary. This correction was obtained from the temperature pressure tests recently made on these instruments by the Bureau of Standards. The strut thermometer was not tested as it was damaged subsequent to the flight, but the error in the average temperature of the air column due to the calibration of this thermometer is probably not more than 1 deg. C. If this error were 2 deg. C it would change the computed altitude by only approximately 250 ft.

Both barographs used have excessively large instrumental errors and thus complicate the testing and computation, and introduce uncertainty into the result.

Altitude Determination

Pressure difference from flight-history test	21.67 in.
Correction due to error of Boyce motometer	+0.34 in.
	22.01 in.
Ground pressure, McCook Field, at start of flight (by Weather Bureau barometer corrected for difference in altitude of 150 ft.)	29.49 in.
True pressure at highest point	7.48 in.
Isothermal altitude corresponding to 7.48 in. (A. I. Cir. No. 3)	37850 ft.

THE LEPERE FIGHTER (400-HP. LIBERTY WITH MOSS G. E. SUPERCHARGER) ON WHICH MAJ. R. W. SCHROEDER REACHED A MOST PROBABLE ALTITUDE OF 33,000 FT.
Photo International

Isothermal altitude corresponding to 29.44 in. (ground pressure at time highest point was reached by Weather Bureau barometer corrected for difference in altitude of 150 ft.)	420 ft.
Isothermal difference in altitude	37430 ft.
Temperature correction for height of air column (mean temperature -29.2 deg. C)	5180 ft.
True difference in elevation	32250 ft.
McCook Field above sea level	750 ft.
Probable altitude above sea level	33000 ft.

The folowing results are in accordance with the method of computation specified in the F. A. I. Rules for 1919 as interpreted by the Aero Club of America. In this case the temperature correction to the air column is not applied.

Isothermal difference in altitude as already computed	37430 ft.
McCook Field above sea level	750 ft.
	38180 ft.

Summary

Probable altitude	33000 ft.
Altitude by F. A. I. 1919 method	38180 ft.

Navy Specifications for Two-Place Amphibian Planes

The Bureaus of Construction and Repair and of Steam Engineering, Navy Department, have issued specifications for two-place airplanes capable of being used either as seaplanes or as land planes. Bids on this schedule are to be opened on June 1, 1920.

Characteristics

The functions of the new type which it is desired to develop are considered to be as follows:—

(a) *A plane for use as a seaplane and for use as a land plane.*

The plane is to be so designed that it can be converted into either a seaplane or a land plane by changing the type of landing gear only. The pontoon struts should fit the land chassis strut fittings at fuselage without any readjustment or change. A simple and easily convertible chassis is desired.

It is desired to provide an airplane for the use of aviation units serving with expeditionary and advanced base organizations. The airplane will be used as a reconnaissance, photographic, or bombing plane by varying the load.

Maximum field of vision is to be provided for both pilot and observer. Maximum arcs of fire are to be provided against air attacks. Stick control is to be fitted in forward cockpit only.

(b) *As a land plane.*

A high lift wing section is to be used and the loading per square foot of wing surface and per brake horsepower should be low enough to insure a take-off where only a short run is available, and on ground of the character which is encountered in small fields on expeditionary duty. The plane should have ample propeller clearance and wheels high enough to permit operation over unprepared ground.

(c) *As a seaplane.*

The plane is to be pontoon type and not a boat type.

When weather conditions are favorable the seaplane will be lowered over the side of a ship and required to rise with its own power from the sea. The plane shall, therefore, be provided with a suitable hoisting sling, (General Specifications 100-A paragraph 230) readily accessible to the crew of the seaplane and conveniently arranged for hooking on in a swell with ship rolling. The seaplane shall be stable and controllable when running in a moderately rough sea. Particular attention must be given to the protection of the propeller from spray.

Bidders must show in their designs sufficient evidence of sea-worthiness to convince the Department that the design is worth consideration. Bidders are required to show a stable flotation system; secure against capsizing when at rest on a rough sea; provided with water-tight subdivisions; an excess buoyancy of more than 100 per cent; sufficient clearance under lower wings and tail to keep clear of breaking seas; means for towing consisting of a bridle or lizard secured forward at a suitable point for towing and led back to a point where the crew can conveniently reach it for securing a heaving line.

Favorable consideration will be given to the provision for detaching the wings wholly or in part while adrift at sea. It is contemplated that as a seaplane, the plane will sometimes land in very rough water, and in case of a wreck, it is desired that the flotation elements will remain sufficiently intact and buoyant to float the crew until they can be rescued. (General Specifications 100-A, Paragraphs 341-6).

(d) *Maneuvering in the air.*

In the air the plane both as a seaplane and a land plane shall be in proper flying balance, completely controllable, and in all respects a safe and reliable flying machine.

The inherent stability shall be such that pitching motions die out naturally without the intervention of the pilot; the directional stability such that a given course can be held without undue effort; that on a turn if correctly banked the plane tends to hold this bank; that no abnormal motion is introduced by cutting on or off power. (General Specifications 100-A, paragraph 347).

(e) *Handling and housing.*

The airplane shall be constructed so as to permit ready assembly and disassembly of the principal parts to facilitate stowage aboard ship. Especial attention must be given to rapid and certain alignment of all fixed surfaces, if possible without need for adjustments. Folding wings or quick detaching wings are desired. The airplanes will be housed in a restricted space, but must be in a condition for service in a minimum time, and in any case on not more than one-half hour's notice. The overall span shall not exceed 40 feet, and in general, careful attention shall be given to keeping over-all dimensions of all principal parts to a minimum. All control leads shall be readily accessible and so rigged that correct adjustment of slack is not affected by assembly and disassembly. Gasoline and oil piping and engine controls should be so rigged as to be unaffected by disassembly of the airplane for storage. The complete power plant should remain assembled as a unit.

(f) *Handling Crates.*

The parts of the airplane are to be so distributed among the various crates that they can be readily handled and transported by manual labor without the use of special equipment. The crates shall be reasonably water-tight and so constructed as to permit ready reassembly and recrating, and sufficiently rugged to permit of rough handling.

(g) *Air performance.*

When carrying a useful load of 1300 lb., representing full fuel and such items from the ordnance and equipment listed as the Department may designate, the airplane shall meet the following performances as a land plane—

Low speed (not more than) 45 m.p.h. at sea level.
High speed (not less than) 90 m.p.h. at sea level.
Climb in 7 minutes.....5,000 ft.

(h) *Endurance.*

A gasoline tank capacity of 90 gal. is to be provided.

Aerial Freight Service Begins in July

A large aerial freight transportation system, embracing the entire country, will be inaugurated in July by the Aerial Transport Corporation, according to a recent announcement. Five hundred large British airplanes are to be used in maintaining schedules comprising this system, all of which have been contracted for.

In addition, an allied company, known as the Aircraft Sales Corporation, has been incorporated in Delaware to dispose of 2,500 more British airplanes, 5,000 airplane engines and a vast quantity of aeronautical accessories. The equipment represents part of the surplus aeronautical material left over from the British government's war endeavor.

Some of the country's most famous aviators are officers of the two new companies, among them being Commander P. N. L. Bellinger, who piloted the famous NC-1 in the first transatlantic flight; Colonel R. S. Hartz, who commanded the first airplane to fly around the "rim" of the United States; Major A. W. Harris, late of the United States Air Service, and John A. Jordan, chief of construction, United States Aerial Mail Service. Judge Grey of Niagara Falls, is head of the companies.

The new transport company is obtaining a tract of land in New Jersey which will be turned into the Eastern terminus of the aerial freight carrying system. The services will be inaugurated between New York, Cleveland, Chicago and Minneapolis, in which DH-9a and DH-10 planes will be used. As the operations proceed, the system will include a series of zones which will act as feeders to the main trans-continental service.

The statement announcing the service was issued by W. H. Workman, representative in this country of Handley Page, Ltd.

The Gliding Surface of Seaplane Floats

By Lieut. Col. A. Guidoni
Italian Air Attache, Washington, D. C.

Seaplane floats generally used are of two different kinds. In the first the gliding surface is completely distinct and separate from the float, being formed by a series of ribs placed laterally or under the float; in the second the gliding surface is an integral part of the float, being part of the whole of the bottom.

The calculation of the gliding surface for a given seaplane presents such theoretical difficulties that, nearly always, the surface is established by comparing it with that of a well known machine and by controlling this calculation by means of trials at the experimental model basin.

The *direct calculation* of the gliding surface may be made with satisfactory results in specific cases, that is, when the resistance of the float, due both to the gliding surface and to the keel, can be easily determined.

In the following direct-calculation example, we have some properties of general character that can be applied to all seaplanes. These properties are perhaps more interesting than the calculation itself, which naturally cannot be assumed to be without errors in most of the cases.

Let us take a cylindrical-float seaplane with a separate gliding surface placed under the floats (Naval Architects symbols are used).

Let D = Displacement in cubic meters
L = Length of float
d = Volume of the submerged float at v speed
s = Midship section of the float at v speed
R_x = Coefficient of the aerial drag of the seaplane
R_y = Coefficient of the lift of the seaplane
σ = Gliding surface
$k_x\ k_y$ = Coefficients of the resistance and of the lift of the gliding surface
k = Coefficient of resistance of the craft

The resistence of the seaplane at V speed is the sum:

of the resistance $R_x\ v^2$ in the air;
of the resistance $k_x\ \sigma\ v^2$ of the gliding surface;
of the resistance $k\ s\ v^2$ of the craft;

$$s = \frac{d}{L} \qquad d = D - R_y\ v^2 - k_y\ \sigma\ v^2$$

$$s = \frac{D - R_y\ v^2 - k_y\ \sigma\ v^2}{L}$$

The total resistance is then:

$$R = R_x\ vz + k_x\ \sigma\ v^2 + h\ \frac{D - R_y\ v^2 - k_y\ \sigma\ v^2}{L}$$

Therefore the total resistance is a function of v and σ

$$R = (a - b\ v^2)\ v^2\ \sigma + (c + dD - e\ v^2)\ v^2$$

Differentiating with respect to v and equating the result to O we have then an equation which can be solved with respect to v.

$$(2av - 4\ bv^3)\ \sigma + (2dDv - 4\ ev^3) = O$$

$$v = \sqrt{\frac{a\ \sigma + c + dD}{2b\ \sigma + 2e}} \qquad \ldots\ldots(1)$$

The value of v is called *critical speed* because to it corresponds a *maximum resistance.*

Substituting v in the expression of R and simplifying, we have:

$$R_{max} = \frac{a^2\ b\ \sigma^3 + (a^2\ e + 2abc + 2abdD)\ \sigma^2}{(2b\ \sigma + 2e)^2} +$$

$$+ \frac{(2aec + 2aedD + 2bcdD + bc^2 + bd^2\ D^2)\sigma}{(2b\ \sigma + 2e)^2} +$$

$$+ \frac{ec^2 + 2ecdD + ed^2\ D^2}{(2b\ \sigma + 2e)^2} \qquad \ldots\ldots(2)$$

The value of maximum resistance is therefore function of the gliding surface σ and of the displacement D.

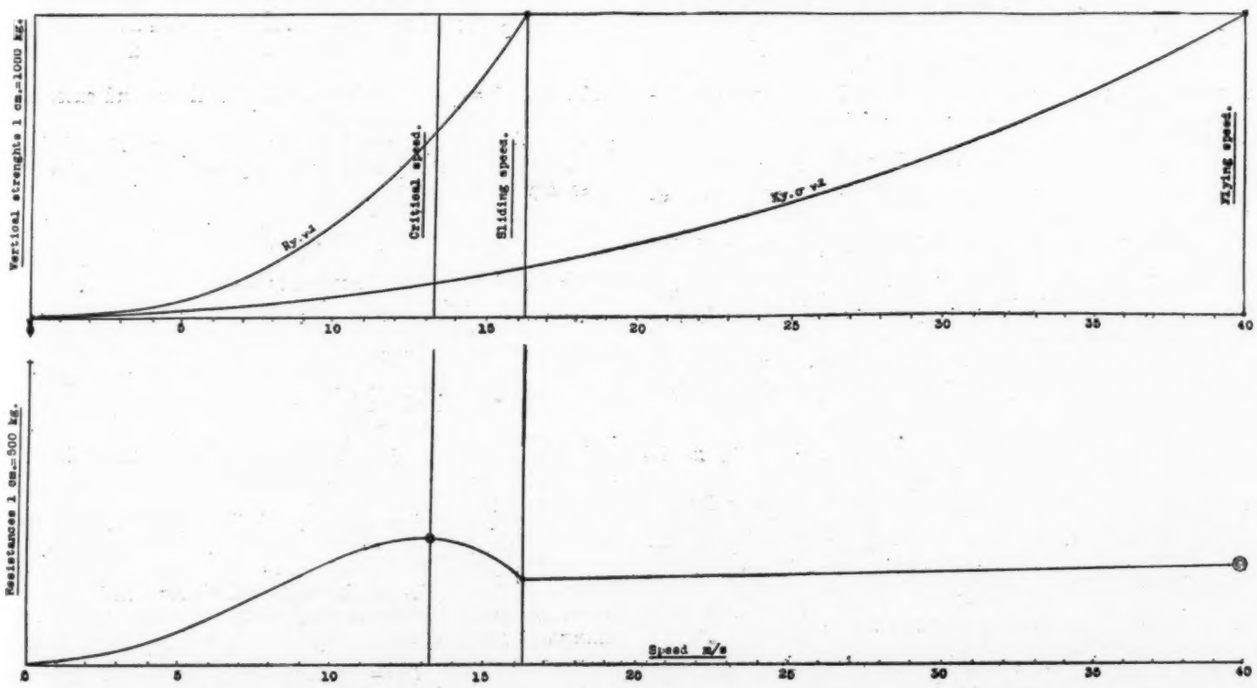


FIG. 1

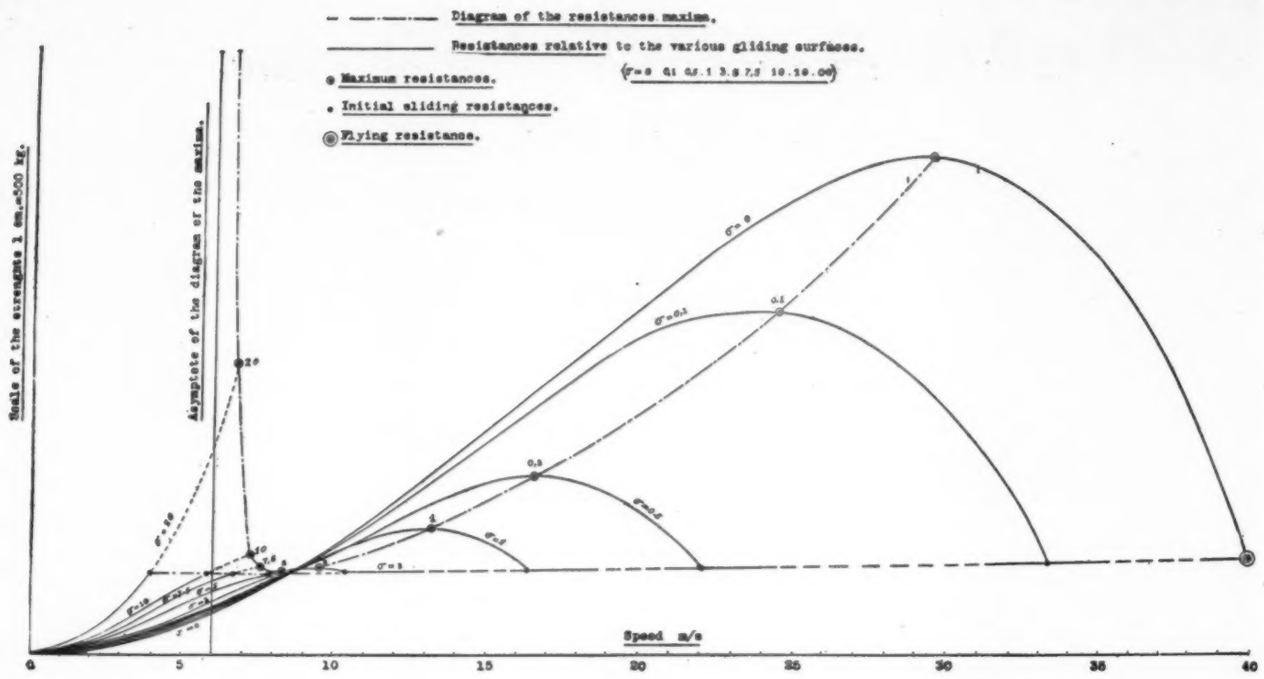


FIG. 2

On tracing the usual diagrams of the static and dynamic vertical thrusts and of the resistances of a seaplane (Fig. 1) if the gliding surface σ has been happily selected the resistance changes according to a characteristic curve which after reaching a maximum decreases down to a minimum point, thereafter maintaining a constant course or nearly so. The minimum value is called *gliding resistance* and corresponds to a *gliding speed* (v) which is the minimum at which the weight of the seaplane D is completely compensated by the dynamic thrust of the hydro and aerial lifting surfaces.

$$D = R_y\, v_1^2 + k_y\, \sigma\, v_1^2$$

$$v_1 = \sqrt{\frac{D}{R_y + k_y\, \sigma}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

From this point

$$R = R_x\, v^2 + k_x\, \sigma\, v^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and as the plane continues to rise and σ continues to decrease, the value of R remains practically constant. The sliding resistance is:

$$R_1 = R_x\, v_1^2 + k_x\, \sigma\, v_1^2$$

The foregoing equations (1), (2), (3), (4) lead to interesting theorems.

Applying the law of mechanical similitude, it is found that *if two seaplanes are mechanically similar, the gliding surfaces, the critical and sliding speed, and all geometrical and mechanical elements are similar, according to the ratio established by the law of similitude.*

This theorem is scarcely applied in practice, owing to the fact that, velocities vary according to the $\sqrt{\alpha}$ and the powers

$$\frac{HP}{D}$$

according to α 7/2, the ratio varies according to $\sqrt{\alpha}$. In general practice, however, it is a matter of passing from a known seaplane to another, keeping the same H. P. weight; that is, the same speed; but in this instance the similitude law can only be applied in a very approximate manner. Let us consider the similitude coefficients in the general case.

Weight strengths $\alpha\ p$
Speeds $\alpha\ p$
Powers $\alpha\ n$
Volumes $\alpha\ h$
Surfaces $\alpha\ 2/3h$
Dimensions $\alpha\ 1/3\ h$

Among the exponents must exist the following equations:

$$p = h \qquad n = m + p$$

$$\frac{2}{3}h = p - 2m$$

This relation results because the surface multiplied by the square of the speed gives a power of:

$$\frac{2}{3}h + p\ 2m = p$$

In the case of mechanical similitude

$$p = 3 = h \qquad m = \frac{1}{2} \qquad n = \frac{7}{2}$$

and thus $\frac{2}{3}h = p - 2m$ is satisfied. In the second case, instead, wishing that the speeds be the same or $m = D$, and that the weights be in ratio to the cubes, or $p = 3$, it is not possible to satisfy the equation

$$\frac{2}{3}h = p - 2m$$

We should admit the following ratios:

Weight strengths α^3
Speed 1
Power α^3
Volumes $\alpha\ ^9/_2$
Surfaces $\alpha\ ^3$
Lengths $\alpha\ ^3/_2$

and this can only be done in an approximate manner, in assuming the length of the float as constant.

In this instance we could say:

If two seaplanes have equal speed, the gliding surfaces are to each other approximately in the ratio of the weights and of the motive apparatus.

Numerical example—In the numerical expressions 1, 2, 3, 4, let us give to D and to the coefficients the several values relating to a practical case.

$$D = 10 \text{ tons} \quad (m^3)$$
$$L = 14\ m$$

COMPARATIVE TABLE OF SEAPLANE FLOAT PERFORMACE

GLIDING SURFACE σ (sq. m.)	CRITICAL SPEED V (m./sec.)	MAXIMUM RESISTANCE R_m (kg.)	SLIDING SPEED V_1 (m./sec.)	SLIDING RESISTANCE R_1 (kg.)
0	29.50	8200	40	1660
0.1	24.50	5600	33.2	1560
0.5	16.50	2900	22	1435
1	13.20	2050	16.3	1390
3	9.50	1400	10.3	1360
5	8.30	1350	8	1348
7.5	7.70	1420	6.6	1345
10	7.30	1600	5.7	1341
20	6.85	4750	3.9	1338
∞	6.00	∞	0	$\infty x0$

$k = 25$kg/ sq. m. m/ sec.
$k_x = 4$kg/ sq. m./ sec.
$k_y = 30$ kg/ sq. m m./ sec.
$R_x = 1$
$R_y = 6$
$V_o = 40$ m. sec flying speed

The coefficients are:

$a = 4$
$b = 0{,}054$
$c = 1$
$d = 1.8$
$e = 0.011$

The expressions (1), (2), (3) and (4) become:

$$R_{max} = \frac{860\,\sigma^3 + 8408\,\sigma^2 + 21062\,\sigma + 4{,}057}{(108\sigma + 22)^2} \times 1000$$

$$v = \sqrt{\frac{4\,\sigma + 19}{108\,\sigma + 22}} \times 1000$$

$$R_1 = (1 + 4\sigma)\ V_1^2$$

$$V_1 = \sqrt{\frac{10000}{6 + 30\,\sigma}}$$

By giving to σ increasing values, we now calculate the corresponding values of V and R_{max}, of V_1 and R_1 (see table) and embody them in curves (Fig. 2).

With the general formula, we calculate the resistances for the same values of σ :

$$R = (4 - 0{,}054 \times v^2)\ v^2 \times \sigma + (19 - 0.011\ v^2)\ v^2$$

From the examining of the $R_{max}\ \sigma$ and the R_v curves we deduce that:

In a seaplane of a given weight if the gliding surface varies, the maximum resistance R_{max} also varies, and precisely, *with the increasing of the gliding surface, the maximum resistance decreases until it reaches a minimum which is the best value of the gliding surface.*

This minimum value of the maximum resistance possesses interesting characteristics because it sets a limit for the surface, beyond which is is useless to increase its extension.

In the case in question this value is 4.6 sq.m. and it may be found analytically or by means of the diagram, observing that the sliding resistance of the gliding surface of said value equals the maximum resistance.

$$(1 + 4\sigma)\ \frac{10000}{6 + 30\sigma} = \frac{860\,\sigma^3 + 8408\,\sigma^2 + 21062\sigma + 4052}{(108\,\sigma + 22)^2}$$

from which equation we have σ.

By letting σ increase further, the values of the maximum resistance become theoretical quantities, inasmuch as before reaching the critical speed, the vertical dynamic thrust equals the weight, that is, the sliding speed becomes less than the critical speed.

Regarding these values of the gliding surface, the resistance is no more a maximum but an edge corresponding to the sliding surface.

The curve of $R_{max}\ \sigma$, beginning from the minimum value, re-ascends and becomes asymptotic for a value of the speed v corresponding to $\sigma = \infty$ (see table); this part of the curve is purely theoretic: to materialize it would be necessary to have the seaplane keep all its gliding surface immersed, even beyond the sliding speed.

It has been pointed out that it is not advisable to exceed the value of the best gliding surface; but if we study the curve of Fig. 2, it appears that the gliding surface may not have exactly the best value, for, without inconvenience the surface could be lessened considerably without causing the maximum resistance and the critical speed to increase proportionately.

For instance (see table) by reducing the sliding surface from 5 sq. m. to 3 sq. m., the R_{max} increases from 1350 *kg.* to 1400 kg. (only 50 kg) and the critical speed from 8.30 m./sec. to 9.50 m./sec. If the plane is a slow one, it is not advisable to lessen to an appreciable degree the sliding surface; but, in the case of a fast machine with a considerable propelling power/ kg, it is not essential to adopt large gliding surfaces.

What has been said concerning floats with a separate gliding surface refers also to the gliding-bottom floats, with the exception that the coefficients k, k_x, and k_y are different and cannot be considered uniform.

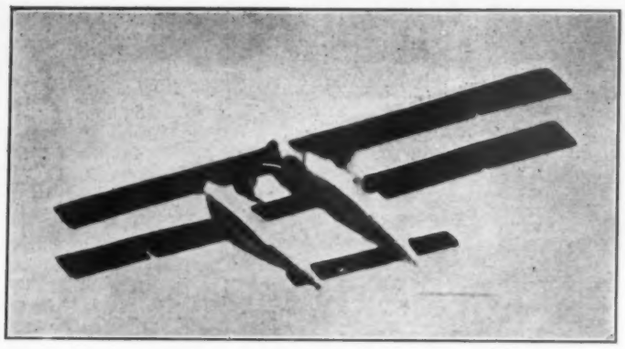
If this study has shown that the required gliding surface can be calculated with satisfactory exactness, thereby obviating the needless exceeding of the dimensions, the ratio of the surface to the weight constitute a serious obstacle to the increasing of the size of the plane, as the weight of the floats increases far more rapidly that that of the plane.

Large seaplanes, consequently, more than large airplanes, require great and greater ingenuity of solution by the designer, lest, due to excessive weight and encumbrance of tne floats, the characteristics of the plane result unsatisfactory.

The Ricci Commercial Seaplane R-I

The Ricci Type R-1 commercial seaplane was built to the designs of the Ricci brothers by the Industrie Aviatorie Meridionali, at Naples, Italy. The machine is noteworthy for its flotation system, which consists of two paralell hulls of general flying boat type, and for the location of the passengers, who are accommodated in a cabin situated in the center section, with the roof flush with the upper plane.

The power plant consists of three Isotta-Fraschini model V .6 engines of 220 hp. each, two of which are mounted outboard in wing nacelles, while the third engine is fitted in the nose of the center nacelle. The wing propellers are



RICCI COMMERCIAL SEAPLANE R. 1 IN FLIGHT

When the Ricci R .1 is used for the carrying of mail and freight, compartments are fitted for this purpose in the forward portion of the two hulls. The center cabin then accomodates two pilots forward, the fuel and oil tanks in the middle, and a mechanician aft. When the machine is used as a passenger carrier, the center nacelle is fitted as cabin for ten passengers beside the regulation crew of three, and the fuel and oil tanks are mounted in the hulls.

The twin hull system has been adopted with a view to affording a strong and rigid support to the tail planes. These consist of a non-lifting stabilizer and a one piece elevator. On top of the stabilizer are mounted three triangular vertical fins and three balanced rudders.

Another object the twin hull system answers is to distribute the masses and stresses over the whole structure as evenly as possible, and to reduce the dead weight of the floating portion.

The two hulls are built of two-ply cedar and are divided into a number of watertight compartments fitted with inspection ports. They are braced to one another as well as to the main planes by means of tubular steel struts.

The upper plane is rectilinear in front elevation. The lower plane is parallel to the upper plane in the center section, while the outer panels are set at a slight dihedral. Ailerons are fitted to both upper and lower plane.

The ailerons, rudders and the elevator as well as the interplane struts and the framework of the wings are constructed of steel tubing.

Following is the specification of the Ricci R .1 seaplane:—

SPECIFICATION

Span, upper and lower plane	85 ft. 9 in.
Overall length	42 ft. 10 in.
Maximum height	13 ft. 10. in.
Total wing area	1,300 sq. ft.
Weight empty	6,160 lb.
Useful load	4,760 lb.
Weight loaded	10,920 lb.
Total horsepower	660 hp.
Maximum horizontal speed	100-110 m.p.h.
Endurance	4 hr
Safety factor of planes	6

Forest Products Laboratory Celebration

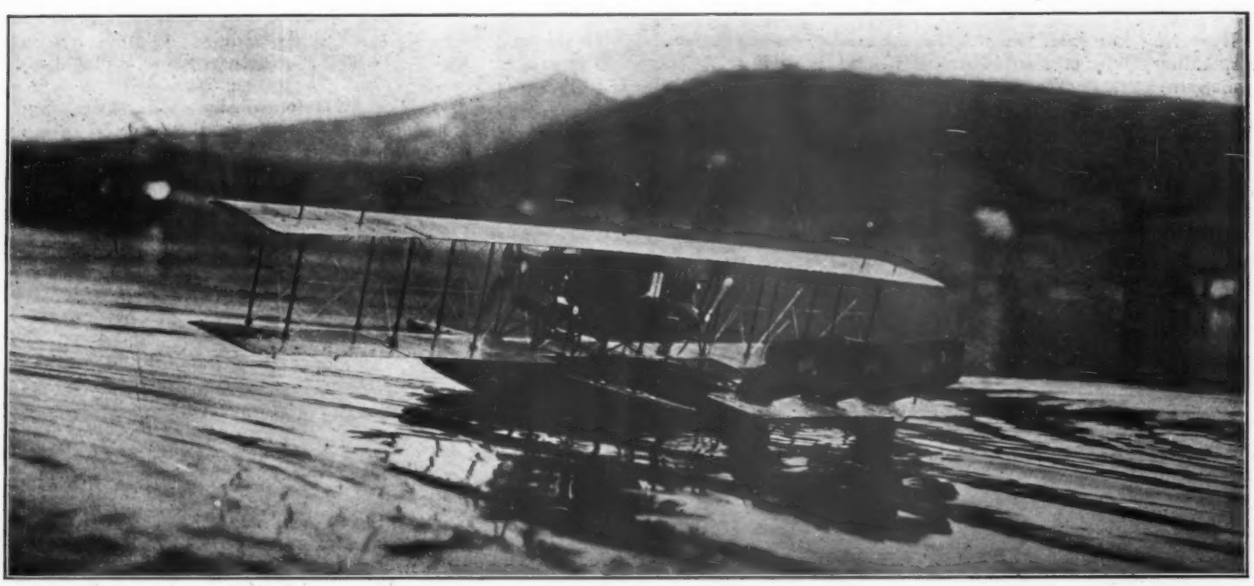
The Forest Products Laboratory was organized by the U. S. Forest Service in 1909 and formallly opened in June, 1910. It is conducted in cooperation with the University of Wisconsin.

During the ten years of its existence the efforts of the laboratory have been devoted to the development of improved methods and processes for the better utilization of forest products of all kinds, and to the direct assistance of the industries concerned.

During the war direct assistance was rendered the War and Navy Departments and various other branches of the Government in the solution of many important problems, particularly in connection with aircraft, gun-stocks, artillery wheels, escort wagons, and the boxing and crating of arms and stores for overseas shipment. It was necessary, throughout this period, to abandon all work on the regular peacetime program.

A good many men acquainted with the work of the laboratory have expressed the thought that the laboratory and the service rendered by it should receive some mark of recognition or appreciation from the industries which it serves. In response to this thought, the decennial celebration has been planned, and the General Committee organized to carry out the detailed arrangements.

The present plan calls for a two-day program, including addreses by men prominent in science, industry, and commerce; inspection of the laboratory; a banquet; and various other forms of instruction and entertainment. It is proposed to make a permanent record of the decennial in the form of a souvenir publication to contain all of the addresses and other relevant matter, including all the names of those who can permit a permanent record of their cooperative contributions to be made.



THREE-QUARTER REAR VIEW OF THE RICCI R. 1 COMMERCIAL SEAPLANE

The Loughead Sport Biplane

General Description. The Loughead sport-biplane is a single-place airplane designed to give a good machine at a minimum of expense. It embodies no radical departures from standard aircraft design, and has an excellent performance.

Every thought has been taken to make the plane a "one man job," and the result is that practically any small field or country road becomes an aerodrome to the owner of a Loughead sport biplane. The patented wing folding feature reduces the housing space required to such an extent that any good garage is a suitable hangar. The simplicity of the power plant eliminates the need for expert mechanics ,and brings the cost of operation down.

Special Wing Control. In addition to the conventional controls, a lever is placed at the side of the seat which throws the lower wings into a vertical position through an arc of 90 degrees, thus placing them in a convenient position for folding alongside the body, and also providing an extremely effective air-brake which makes it possible to stop the plane within from 50 to 75 ft. of the point where the wheels first touch the ground. At the same time the lift of the wings is reduced nearly 50 per cent so that the plane has no tendency, even in a strong wind, to leave the ground after landing.

Strut Arrangement. The upper and lower wings are supported by a V strut near the wing tips, which is solidly bolted to the upper wing spars and fastened to the spar of the lower wing by a simple, but rigid pipe connection.

Lower Wing. The lower wing is similar in form to the upper, except that one deep spar serves to brace the wing in all directions. The spar is pivoted at the body, and at the lower end of the V strut, allowing the whole wing to rotate, and it is this action which affords a very simple and efficient lateral control. The pivotal point is just forward of the center of pressure of the wing, so that there is very little strain on the lever mechanism which transfers the motion of the control stick to the wings.

This system of control eliminates all lost motion and friction found in the conventional cable and pulley systems, and will last as long as the plane, eliminating all cable replacements necessary with conventional types.

Wires. There are only five wires on each side of the body —three flying, one landing, and one drift. This combination gives a trussing system which is simple, having fewer wires than a single cell of an ordinary biplane, and at the same time retaining great strength. All are large 19-strand cable, carefully streamlined. Control cables are enclosed.

Fuselage Construction. The fuselage of the sport biplane is of the well-known monocoque type, consisting of a thin shell of plywood reinforced by transverse bulkheads, of perfect streamline.

In the new process evolved by the Loughead Aircraft Co., arrangements have been made to handle the many strips composing one complete layer of plywood as a unit. The three complete layers of plywood are successively applied to a mold which determines the shape of the body, binding cloth and water-proof casein glue being applied between the layers. The three layers are then subjected to a uniform air pressure of 20 lb. per sq. in., which is maintained over the entire surface until the glue has set.

This process produces a plywood shell of a uniform thickness of 1/8 in., which is extremely strong for its weight.

At all points of attachment of the landing gear, wings, struts, etc., the weight is evenly distributed over large areas through reinforcing blocks and plates.

Upper Wings. The upper wing is built in three sections. The fuel tank is located in the forward part of the center section, and the trailing edge is hinged at the rear spar permitting it to be raised when pilot is getting in or out of cockpit. Simple, but very rigid latches hold it in place during flight.

The fact that no ailerons are employed makes it possible to use the most efficient semi-elliptical form for the wing tips on both the upper and lower planes. The entering edge is spruce plywood, routed out except at points of attachment, and the trailing edge is of steel wire.

THE LOUGHEAD SPORT PLANE AT THE SAN FRANCISCO AERO SHOW

Tail Surfaces. The horizontal and vertical stabilizers are rigidly braced internally by bracing rods. The main bar of the elevators is a large diameter steel tube, to which the control levers and wires are fastened inside the fuselage. The rudder is constructed in the same manner, and all control wires are made amply strong, so that no external masts and braces are needed.

By removing the quick-detachable aluminum tail-piece all turnbuckles are readily accessible for inspection and adjustments.

Tail Skid. The tail-skid is mounted in such a manner that there is no connection between the fuselage and the skid itself except through its rubber mounting. This minimizes all shocks and makes a mounting that is absolutely dependable.

Landing Gear The landing gear is of conventional type, but it has been simplified and lightened to limits consistent with safety, Rubber shock absorbers are employed, and this unit has a factor of safety of over 10 to 1.

Factor of Safety. A factor of safety of over 6 to 1 by actual sand load test has been maintained throughout the machine. This, coupled with the extremely light wing loading of only 3 lb. per sq. ft., insures sufficient structural strength to withstand the strains of any performance to which it can be subjected.

Finish. The fuselage is finished marron, and the wings cream color. All wires, cables, bolts and metal parts are rust-proofed by a process developed by the Loughead Aircraft Corp., which does not injure the materials and protects them thoroughly.

SPECIFICATION OF LOUGHEAD SPORT PLANE MODEL S-L

Minimum Speed (full load-horizontal flight)	70 m.p.h.
Minimum Speed (full load-horizontal flight)	25 m.p.h.
Landing Speed	25 m.p.h.
Rate of Climb	700 ft. first min.
Service Ceiling	12,000 ft.
Gliding Angle	10 to 1
Weight:	
Empty (with gas, oil, and water 450 miles)	375 lb.
Loaded	600 lb.
Useful load	225 lb.
Fuel consumption	50 miles per gal.
Range of flight (without replenishing fuel)	450 mi.
Wing span (upper)	28 ft.
Wing span (lower)	24 ft.
Over-all width (wings folded-patented)	10 ft.
Height	7 ft. 3 in.
Length	20 ft.

Instruments:—Complete equipment including altimeter, motor thermometer, oil pressure gauge, gasoline gauge, etc.

Position of fuel tank:—In center section with sight gauge always in view.

SPECIFICATION OF LOUGHEAD MOTOR

Number and arrangement of cylinders	Two horizontal opposed
Cylinder material	Special grey cast iron with monel metal water jackets.
Bore	3⅝ in.
Stroke	4½ in.
Normal Brake Horsepower	25.
Propeller speed	1800 r.p.m.
Crank shaft	High grade, heat treated chrome vanadium steel.
Connecting Rods	High grade, heat treated chrome vanadium steel.
Crank Case	Aluminum alloy.
Lubrication	Two high pressure gear type oil pumps maintaining a pressure of 50 lb. to the sq. in. on main and connecting rod bearings.
Carburetor	Special.
Ignition	Two independent high tension Bosch magnetos. Two sets spark plugs.
Fuel consumption	One gallon per hour.
Oil Consumption	One-half pint per hour.
Cooling	Water by forced circulation.
Radiator	Mounted under fuselage. Water tank in cowl.

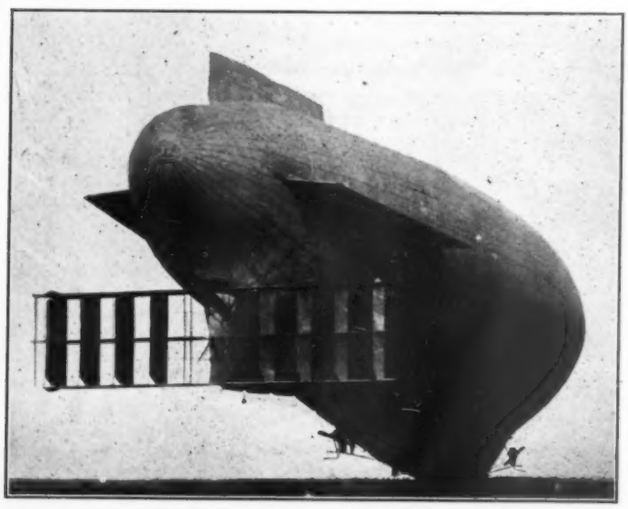
The Italian Airship Roma

The Italian semi-rigid Usuelli airship Roma derives its trade name from the wealthy business man Celestino Usuelli, who constructed it together with Eng. Prassone Eng. De Nobile and Colonel Crocco.

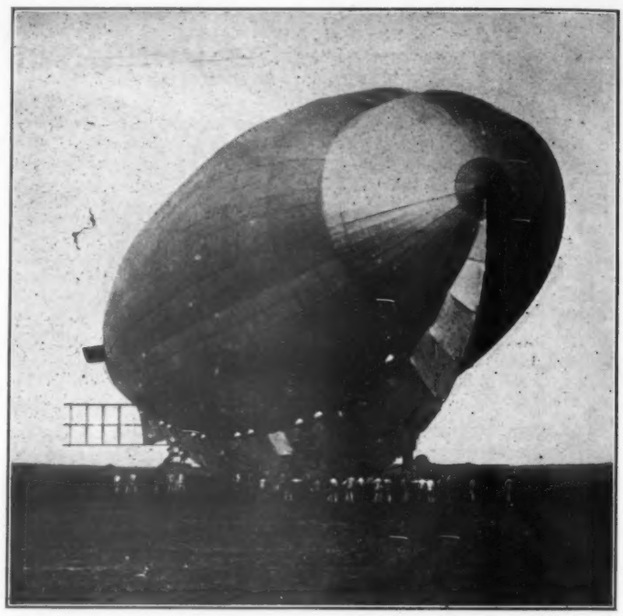
The characteristics are:

Capacity	1,200,000 cu. ft.
Gross weight	37 tons
Fixed weight	18 tons
Disposable lift	19 tons (crew-ballast-fuel)
Length	412 ft. 6 in.
Beam	82 ft. 6 in.
Height	90 ft. 9 in.

The envelope has twelve gas compartments and six air ballonets. A characteristic of this airship is that each of the ballonet divisions has its own air manifold and two controllible exhaust valves.



STERN VIEW OF THE ITALIAN SEMIRIGID AIRSHIP ROMA



BOW VIEW OF THE ITALIAN SEMIRIGID AIRSHIP ROMA

On the bottom of the envelope and under it there runs, from fore to aft, a rigid triangular girder with the apex down. This girder has a 12 in. side and the small parts are made out of steel tubing having articulated couplings to avoid all stresses of secondary flexure and to assure that they will work as a solid of Euler.

The top of the envelope is bi-lunated, much after the fashion of the Astra-Torres, but of smaller proportions. Crossing the main beam there are three longitudinal fabric partitions in which the strengths are attached to the couplings of the girder by means of parabolic ropes.

The envelope is fixed down to wire rope parables deriving from the couplings.

In order to make rigid the nose of the ship in flight, the fore part of the girder is shaped in a large braced cupola.

Six 12 cyl. 400 hp. Ansaldo engines are placed two by two near the fore, the center, and the after part of the ship. Engines and radiators are situated on cantilevers attached and projecting from the central beam.

The first pair of engines have the axis at an inclination of 12 deg. over the diametrical plan of the ship, the second pair have an inclination of 10 deg. and the third have the axis parallel. This is arranged so that the first engines do not interfere with the working of the second pair, nor the latter with the working of the third.

The propellers have a diameter of 11 ft. 6 in. and are directly connected to the engines.

Three fixed rectangular planes or fins and a triplane elevator with multiple rudders are fitted aft.

The control cabin is in the girder. For the steering of the ship there exist two control wheels, one fore and one after.

The speed of the ship will be about 80 m.p.h.

The fuel oil reservoirs are cylinders of 2 ft. 2 in. in diameter and 3 ft. 7 in. in height. Similar receptacles are also used for the water ballast.

In the girder space is provided for the fitting of a spacious salon accomodating 25 passengers.

New Shock Absorber for Balloon Baskets

A new type of basket shock absorber for balloons was recently tested at the Army Balloon School at Fort Omaha, Neb. The basket was dropped from 500 ft. with about 400 lb. of sand therein. The parachute opened in 1 1-5 sec. and the drop took 11 sec., the average velocity being 45 ft. per sec. and the striking velocity being equivalent to a free drop of 14 ft.

Ski Landing Gears for Airplanes

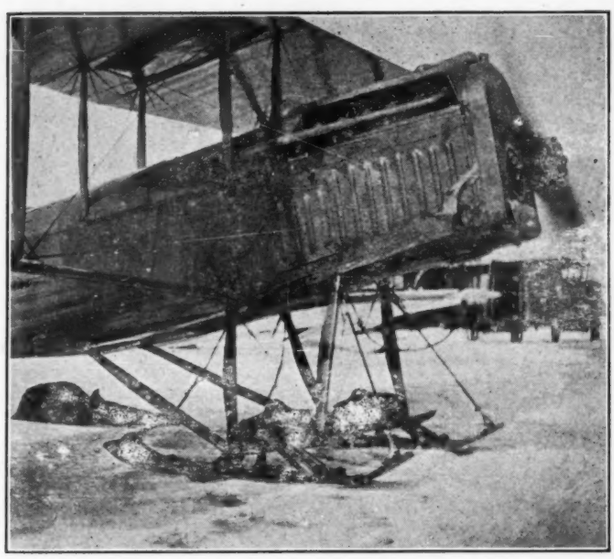


FIG. 1.

The importance of fitting airplanes with ski landing gears in order that they may take off and alight on snow and ice was vividly illustrated last winter, when the mail planes of the United States Post Office Department were unable to operate for several days owing to heavy snowfalls. As a result of this lesson the Air Mail Service has developed a ski landing gear, illustrated in Fig. 1, which it is intended to make a standard fitting for all United States mail planes in such way that the skis will be readily interchangeable with the wheels.

A ski landing gear of somewhat different type is illustrated in Fig. 2, which is that used on Avro 504-K biplanes flying in the Swedish Air Mail Service. The following notes, based on experiences with these machines, were compiled by a Swedish mail pilot and are reprinted herewith from *The Aeroplane*.

"Skis should be fitted to the ordinary axle after removing the wheels, and the fixing should be such that they are free to rotate round the axle, within limits. The front of the skid should be supported from th fuselage by a wire and an elastic shock absorber, so that in the air the nose of the ski is pulled right up against the tie wire fixed to the tail thereof. This makes certain that in landing the tail of the skie touches the and that the nose shall have no chance of digging in.

"Freedom to rotate round the axle is also necessary that the machine may be controlled by the elevators when on the ground, prior to taking off.

"For very low temperatures skis should be of birch, though

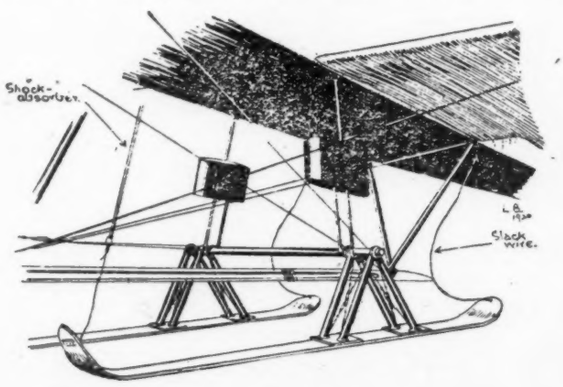


FIG. 2.

if not more than 15 degrees of frost is to be encountered ash is satisfactory. Skis must be impregnated with hot tar, as this improves the running over the snow. If the snow is damp, the skis should be greased with solid paraffin on the bottom. If the snow is very wet, tin sheeting is excellent, but only on very wet snow.

"Skis should be 'hollow ground,' so to speak, to the extent of about half an inch in the center. This gives some grip on the snow and to some extent prevents slithering sideways in a side wind.

"It is very important to jack skis up from wet snow when the machine is standing, otherwise, if it starts freezing, ice forms in the ski bottoms. Ice and snow do not slide well one on the other and such ice will stop a machine getting off.

"For a light machine, such as an Avro, one pair of skis, each about 5½ feet long by 3 inches wide, suffices. For heavier machines the number of skis should be increased, that is, two, three or more pair, arranged side by side, should be employed.

"The usual form of tail skid can be retained as it does not sink far into the snow."

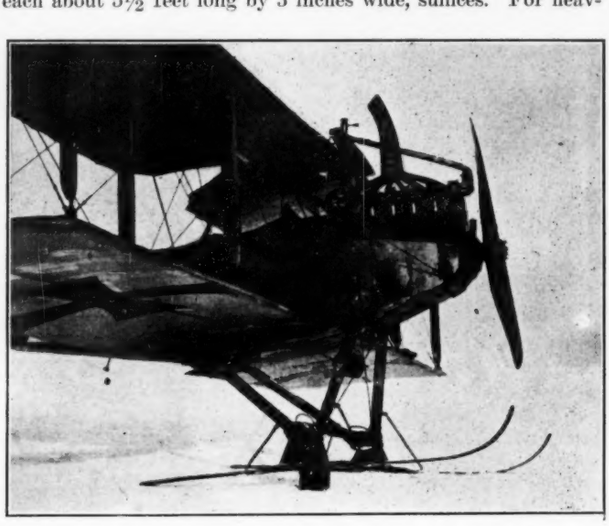


FIG. 3.

Fig. 3 illustrates a ski landing gear attached to a German Rumpler biplane which has been used to some extent in Scandinavia. It may be seen that this gear does not differ materially from that used on the Avro biplanes above mentioned.

Recent Data on Parachutes

By Floyd Smith

During my experimental testing of parachutes and life packs, some unusual problems were encountered, one of the most interesting of which is friction static burns.

At first it was thought to be acid burns, but all acid tests were tried, and none gave the same results. Then, it only required a certain amount of reasoning to determine that a large amount of silk being straightened out of a folded position in a pack, at high speeds, would cause friction, and as silk is very susceptible to static, it may be burned. This theory was further strengthened by the fact that the burns seldom appeared when the air speeds were less than 100 m.p.h., and appeared with greater frequency with higher test speeds.

Fine quality Japanese silk is the most susceptible to static burns, with Habutae a close second, and Shantungs and Shanghais, especially the unbleached being the least susceptible. I only know of one instance of cotton being burned, but silk chutes nearly always get several burns at speeds of more than 125 m.p.h.

Static burns are not dangerous, because silk will not burn unless fed by heat or flame, and the static only feeds it for an instant. I have tested parachutes many times until they were burned as much as ten or twelve times, and then broken them with a heavy load and high speed, without any detrimental effects at the particular location of the burns.

In a properly constructed parachute, the silk has a greater factor of safety than the reinforcements, and the silk does not burn where it is doubled or reinforced. The burns generally range in size from one to six square inches.

Fireproofing does not prevent static burns although it helps a little by reducing the susceptibility of the silk to static.

Cotton is not practical for high speed parachutes although it is much less susceptible to static burns. The four ounce wing cotton is just double the weight of a good Shantung silk with the same tensile strength in the filling and a parachute constructed of the wing cotton will only hold about 75 per cent of the load that a similar silk parachute will hold.

The silk parchute allows a great deal of air to flow through it and thereby forms a shock-absorber in itself, whereas the cotton parchute holds the most of the air and stops very abruptly. This action of both parachutes is much more pronounced at high speeds.

The rate of descent of a parachute with a given load is not controlled entirely by its size. The weave and porousness of the fabric have an important bearing on the rate of descent. For instance, a 1¼ oz. Shantung silk parachute of 28 ft. diameter will descend at the same rate, with a given load, as a 2 oz. Shantung silk chute of 24 ft. diameter.

A full formed parachute will drop about 15 per cent slower than a flat parachute. Forming is accomplished by reducing the circumference towards the outer or shroud edge, thereby giving it a form similar to its form when descending with the load suspended from the shroud or periphery of the chute. The flat chute allows each panel to curve upward between each shroud line, permitting a leakage of air, and interfering with the inside vortex, which is a large factor in suspension and stability.

A full formed chute will not hold near the load that a flat chute will, varying a great deal with the porousness of the fabric. At speeds of 150 m.p.h. or more, a parachute opens to a wide open flat state in less than one second, and the flat chute will open to that position with very little strain on the outer sections. The full formed parachute will not open to a flat state, and the resultant strains, (very similar to the forces around the periphery of a bomb crater,) are expended on the shroud, and the fabric just inside. A parachute can be about half formed, on the outer third of the panels, and result in a slower rate of descent, without greatly impairing the high speed strength.

A parachute opens to a wide state in less time with a heavy load than with a light load. This is more pronounced with small leakage fabric, and at high speeds. With the light load the first half of the opening reduces the speed to a great extent, therefore the last half of the opening is operating at slow speed. The speed of the heavy load is not affected so much, therefore, the last half of the opening is at high speed.

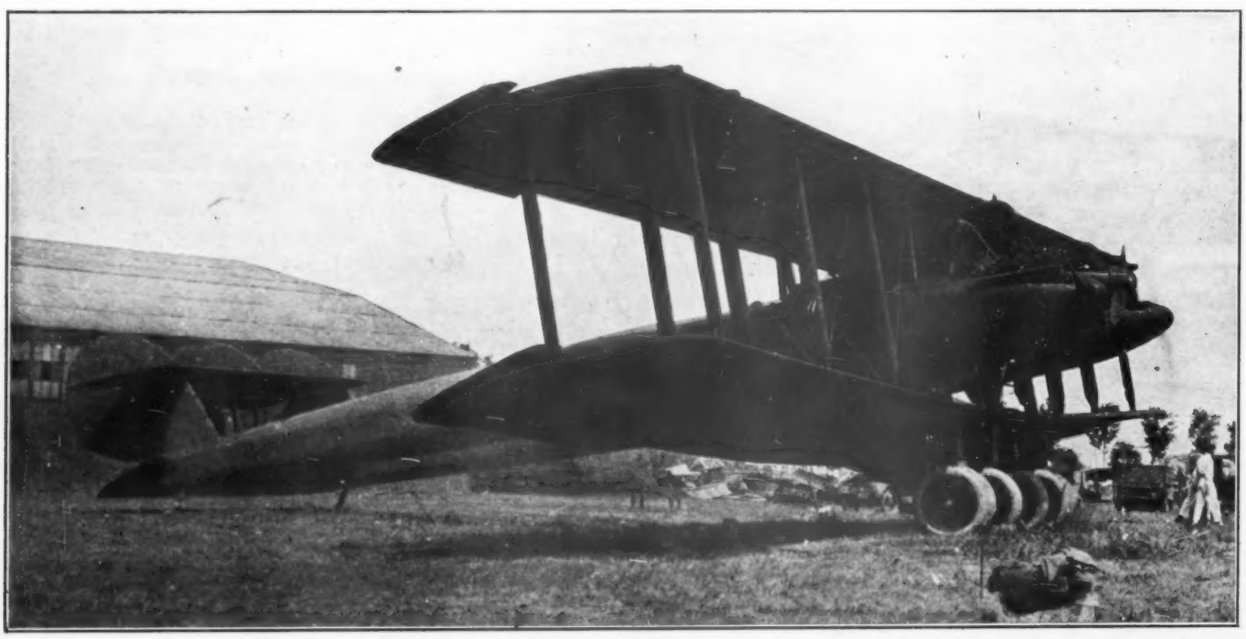
Parachutes will hold a given weight at a higher speed on the horizontal than on the vertical drop, or steep dive. On the horizontal the parachute has only the momentum to stop, and on the dive it has the momentum plus gravity. This is not very important except with heavy weights.

Long shroud lines give a slower rate of descent, and less oscillation in moderate air, but a greater oscillation in rough air. They give a longer swing, and continue the oscillation over a longer period.

Short shroud lines pull the chute in to a smaller diameter, and increase rate of descent, and swing quickly in choppy air, but also lose the swing quicker. Any parachute will oscillate in rough air, but it is not dangerous and can quickly be stopped by pulling on shroud lines on the back of the swing.

A vent in the top of a parachute causes a vortex of air inside which is hard to spill, and therefore resists oscillation. A parachute without a vent will often swing in rough air until it spills air, when that side of the chute will slide off the column of air rushing out, and partially collapse; but this type is only dangerous if near the ground.

I developed what is known as a flexible vent, which has been remarkably successful at enabling a parachute to hold heavy weights at high speeds, when properly constructed. I do not advise its use because it is dangerous under certain conditions, especially when poorly constructed. It is a large vent, 3 to 5 ft. in dia., in the top of parachute, with a chimney of fabric sewed to it, with several cord bridles attached to the top edge of the chimney, with rubbers attached so that normally the top edge is held to the center of the vent thereby closing it. When the parachute opens at high speed or with heavy weight, the inside air pressure overcomes the rubbers, and the chimney is forced up, and open, allowes air to escape and relieve the pressure. When the speed reduces, the rubbers close the vent again to normal condition.



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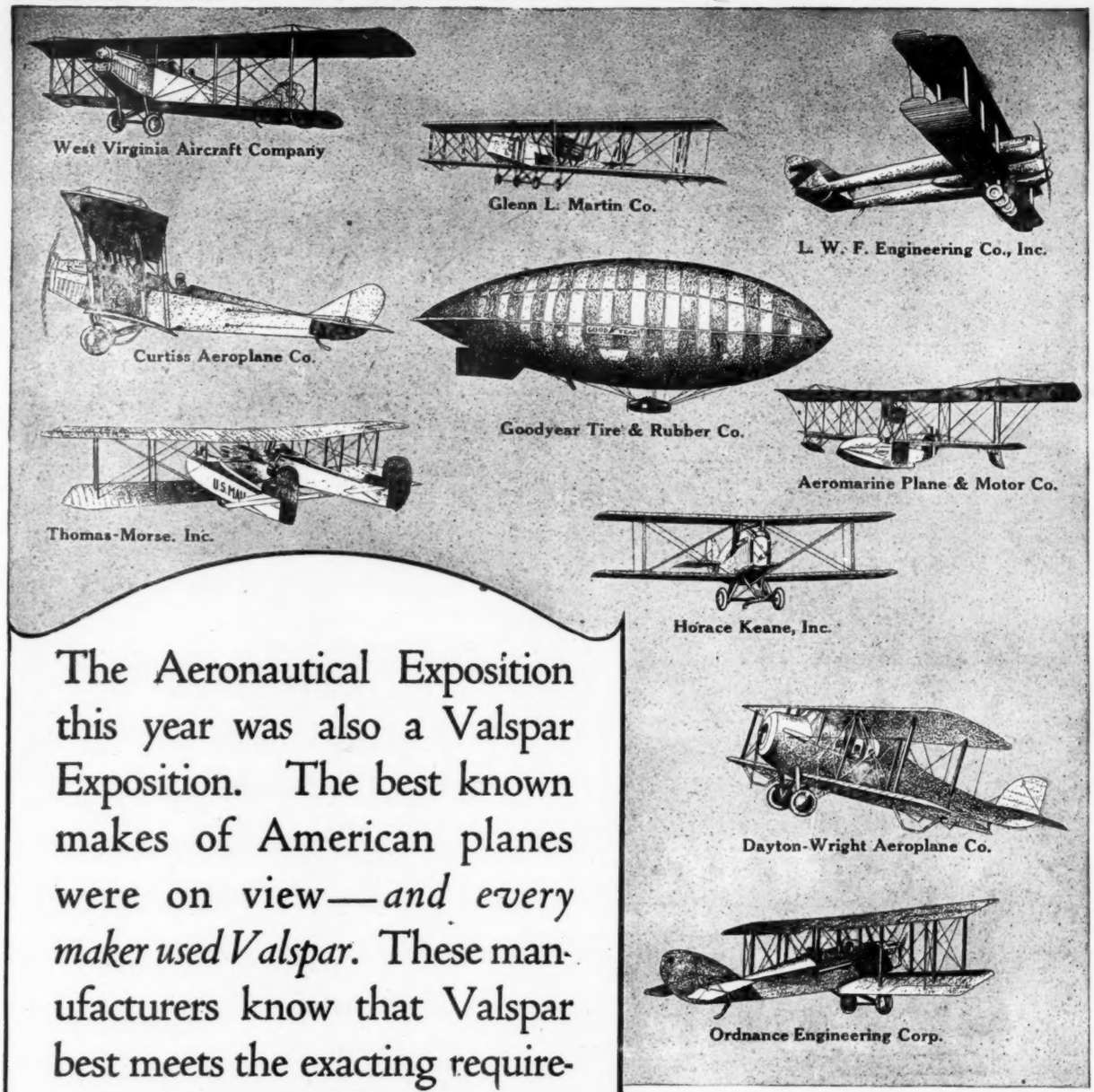

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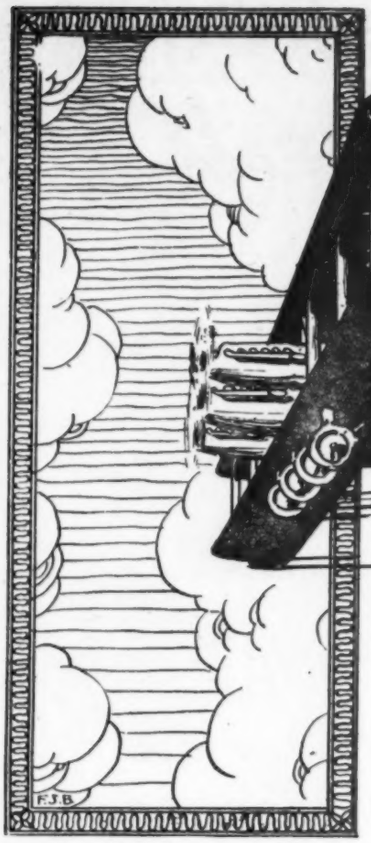

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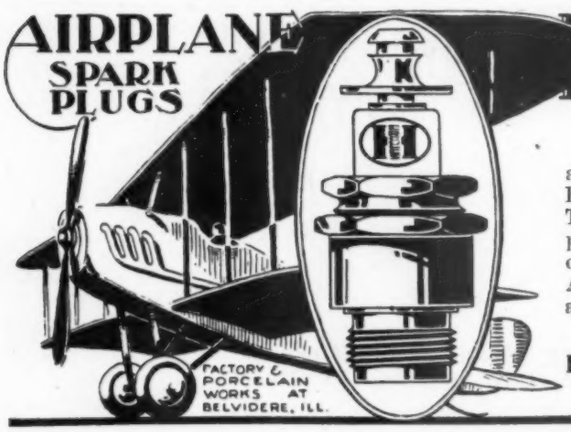

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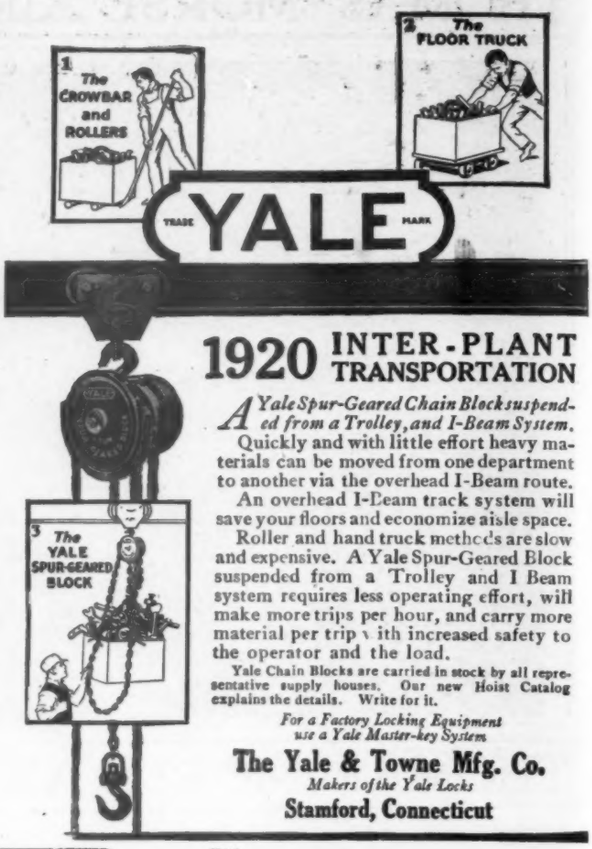

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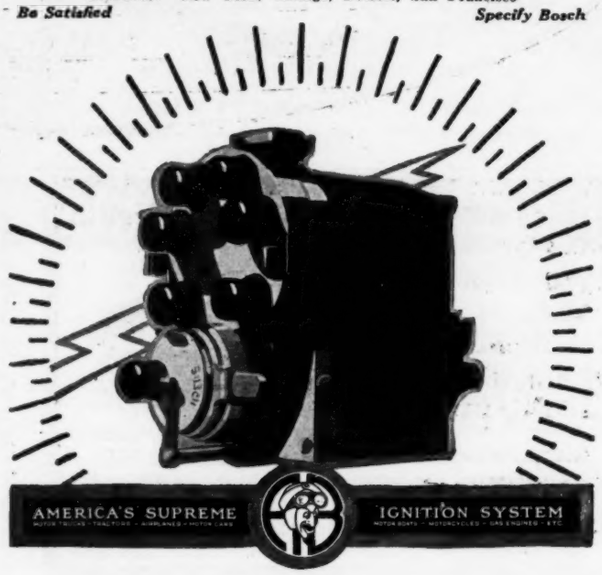

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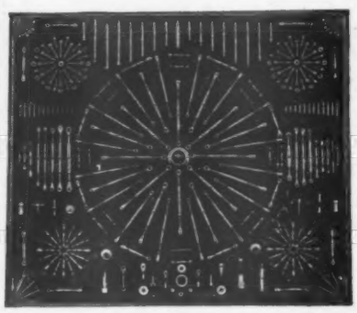

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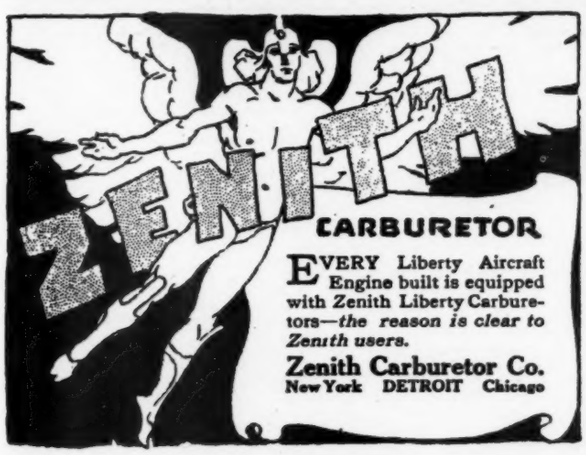
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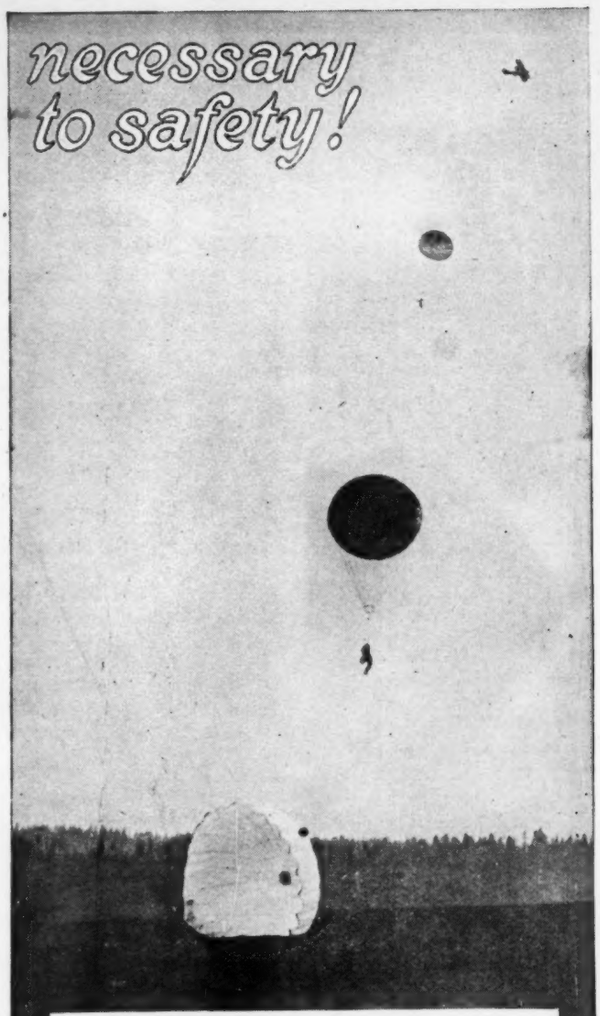

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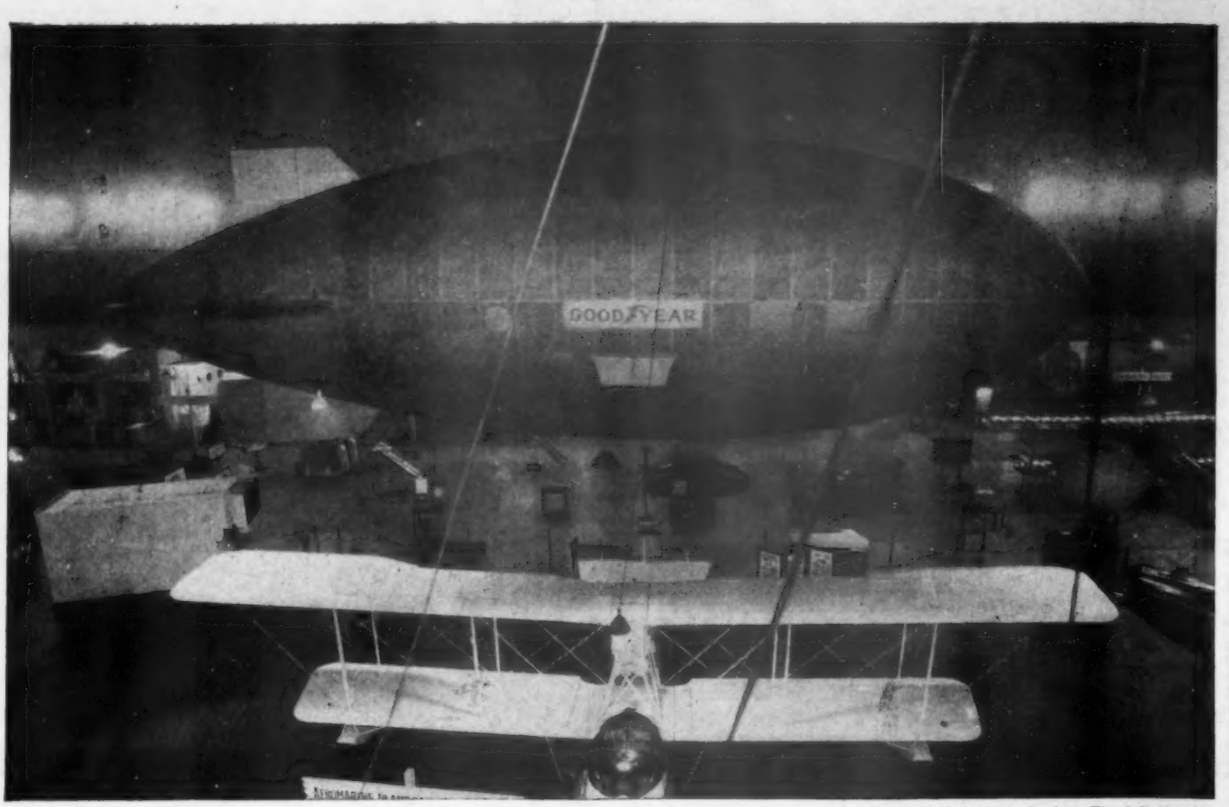

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